FIG. 1

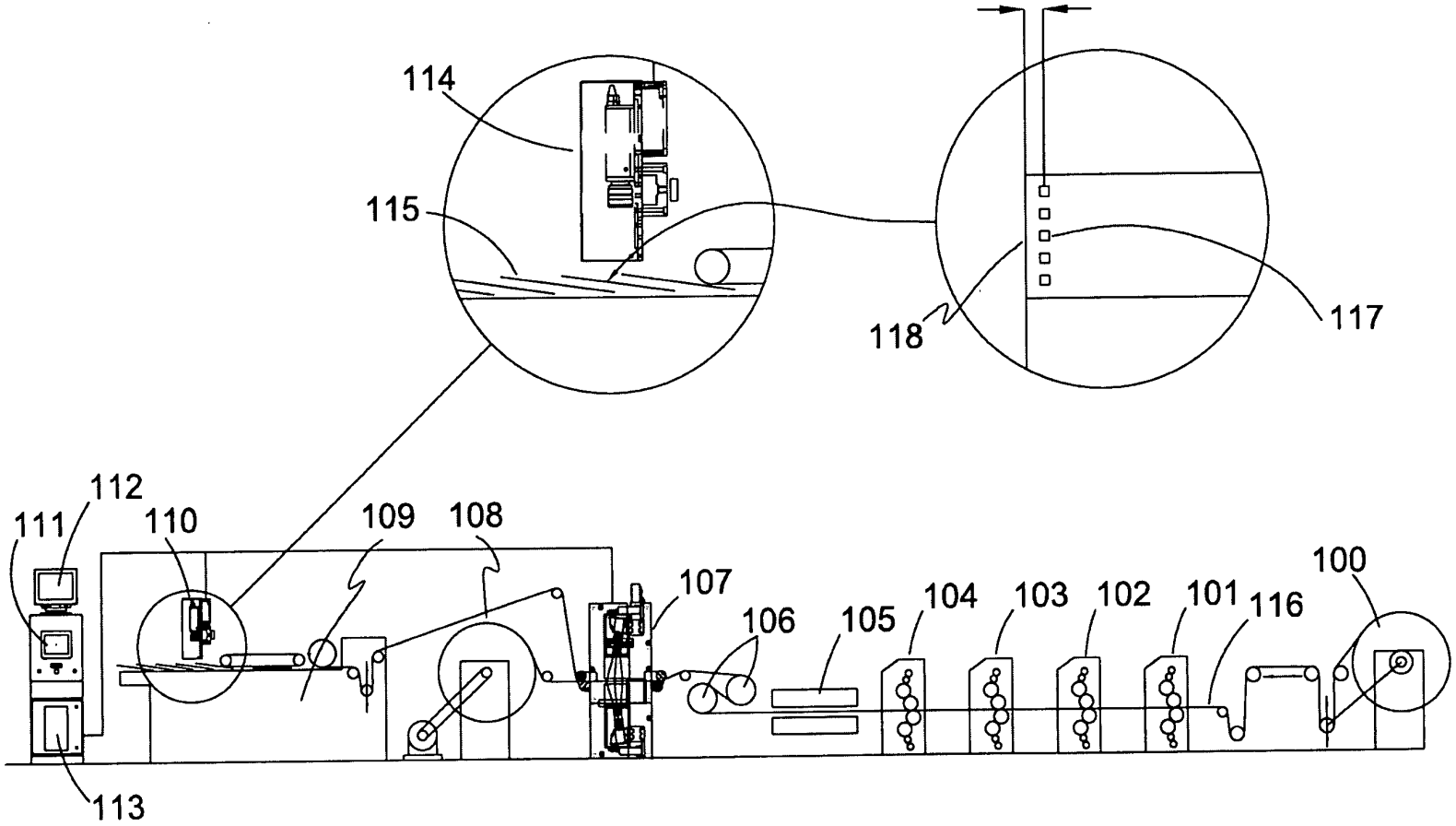

114
115
118
117
112
111
110
109
108
107
106
105
104
103
102
101
116
100
113

FIG. 2

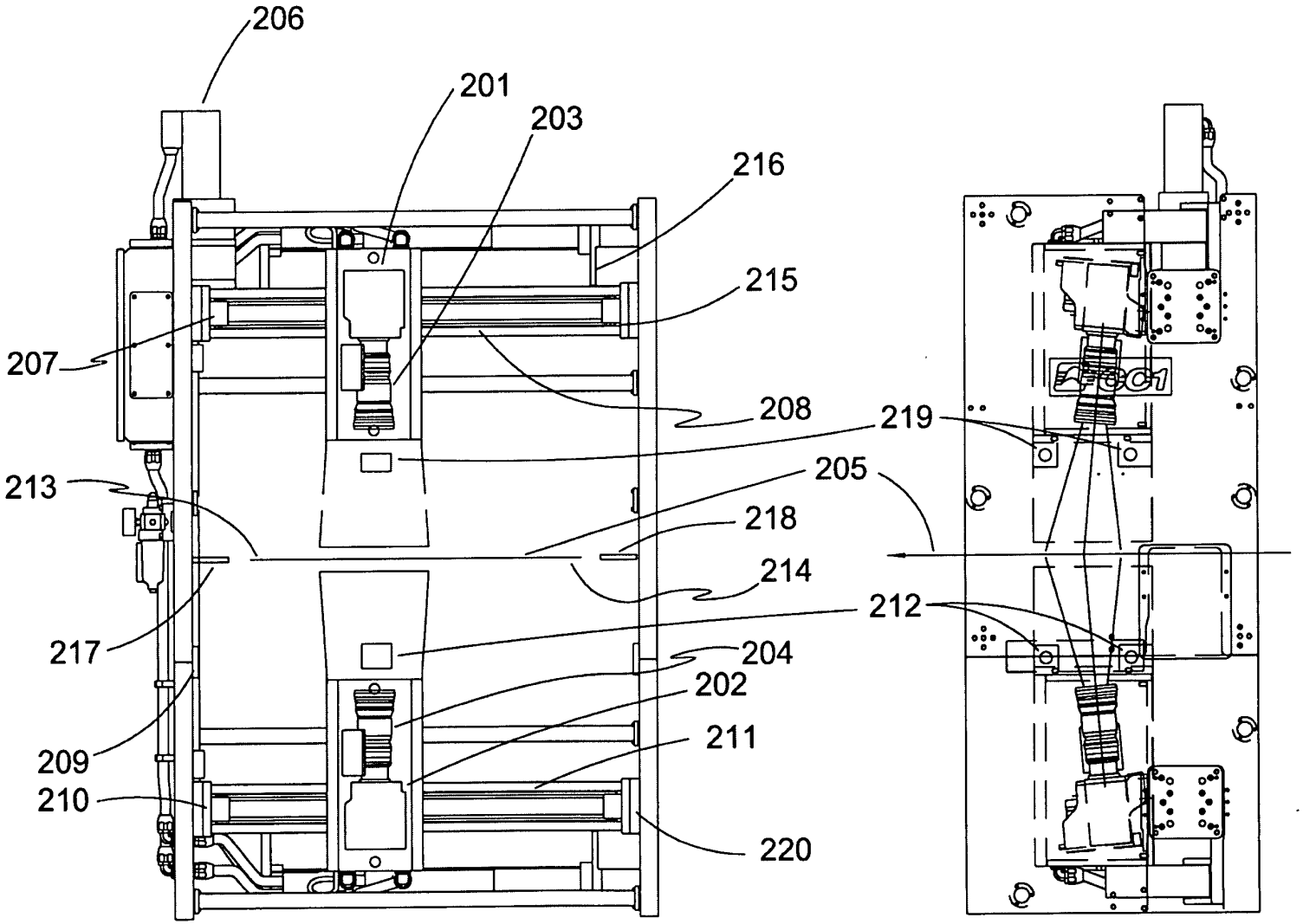

206
201
203
216
215
207
208
219
213
205
218
214
212
217
204
202
209
211
210
220

FIG. 3

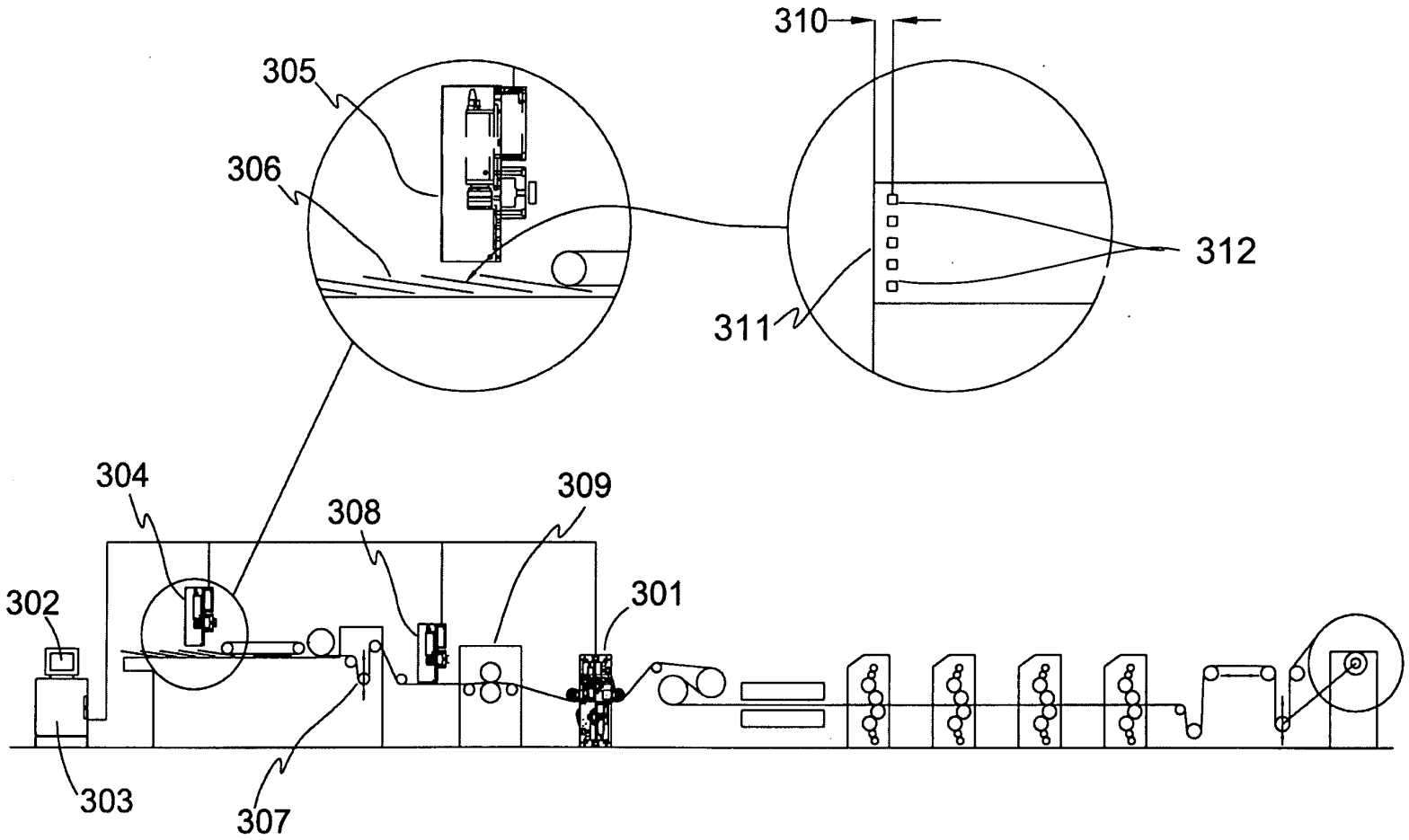


FIG. 4

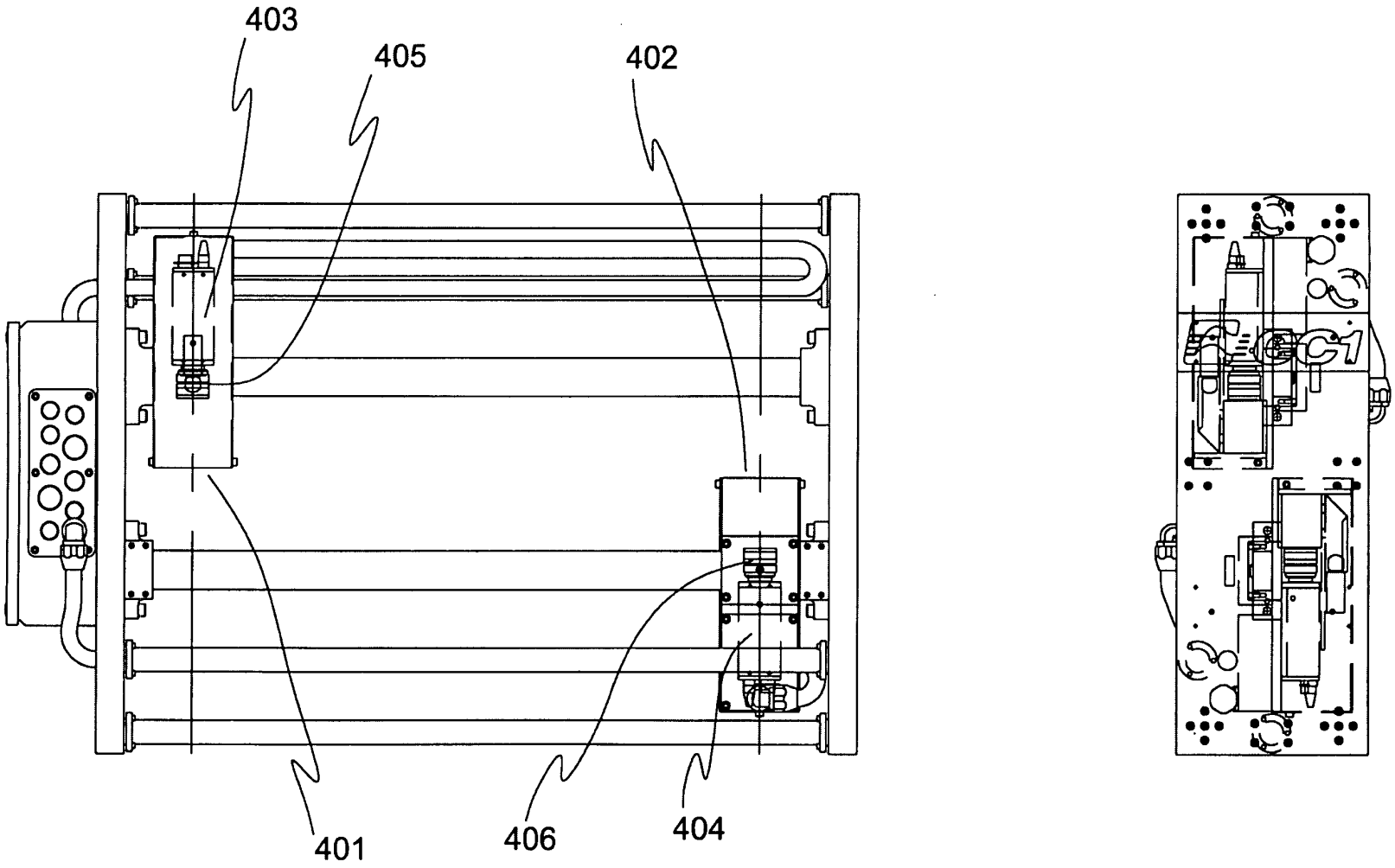


FIG. 5

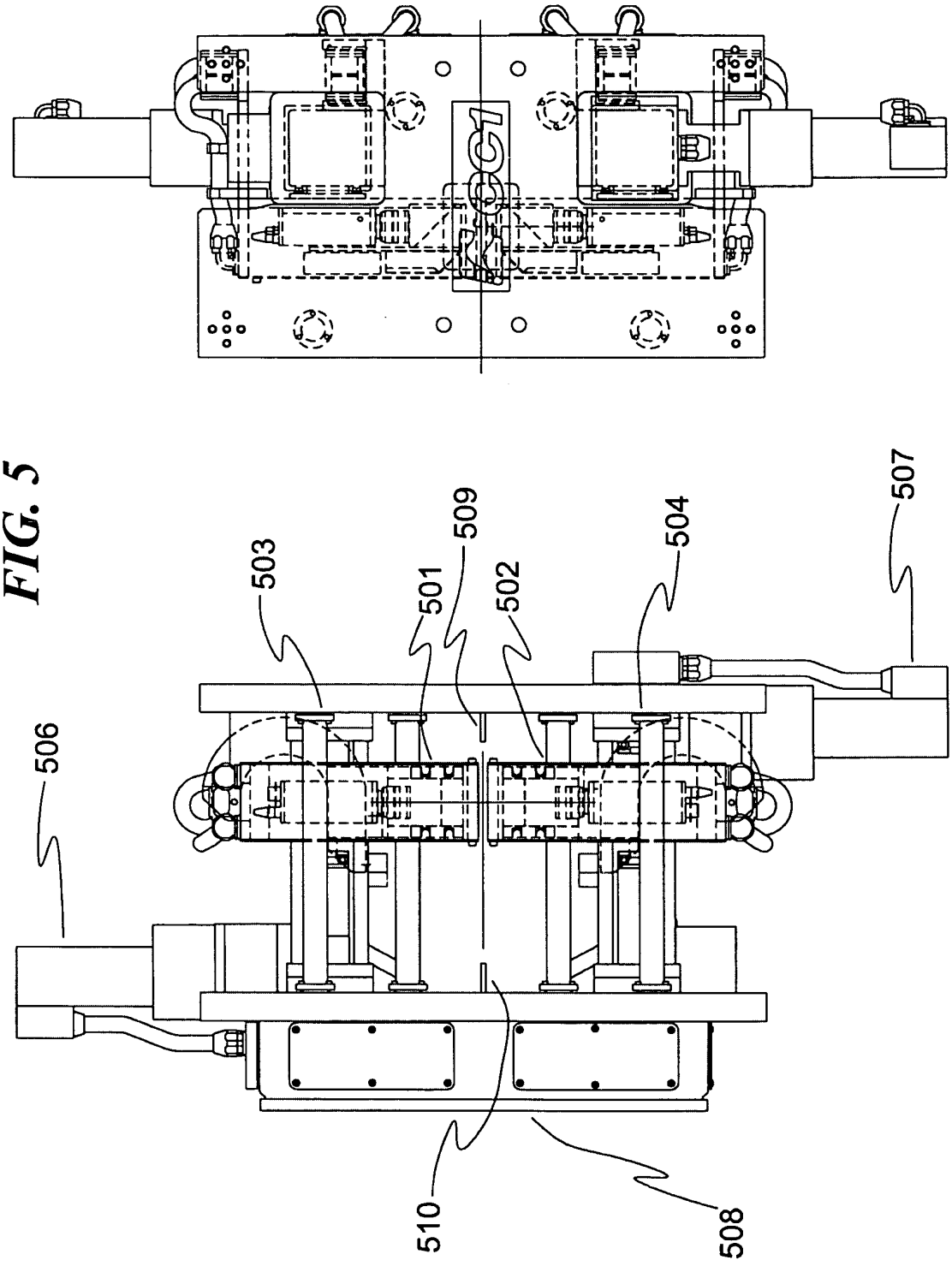


FIG. 6

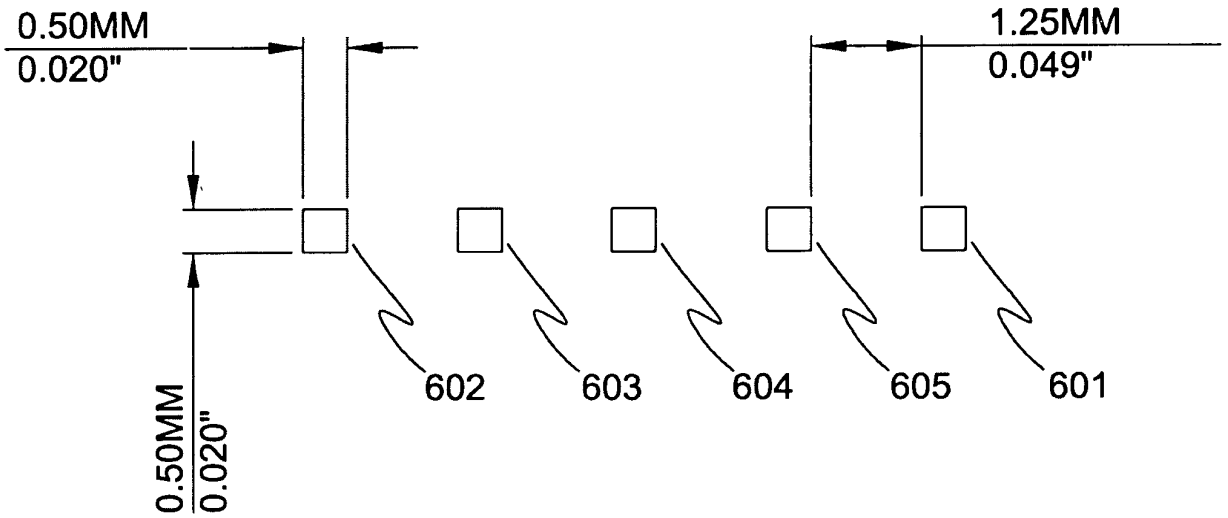


FIG. 7

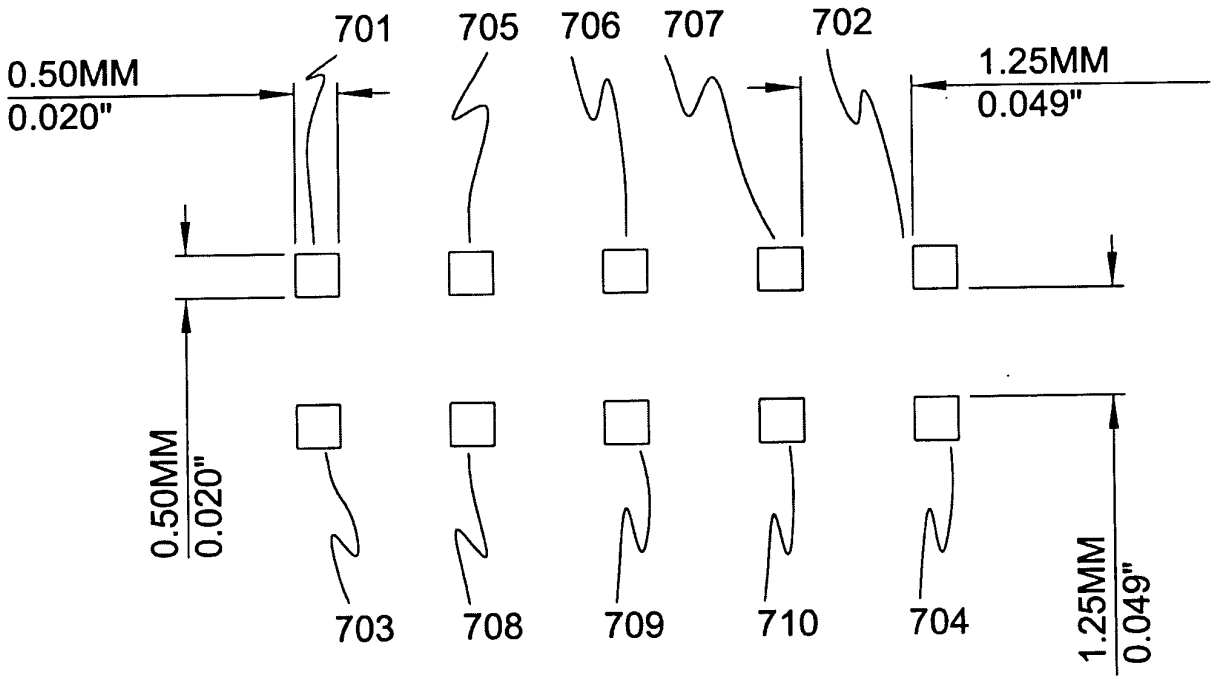
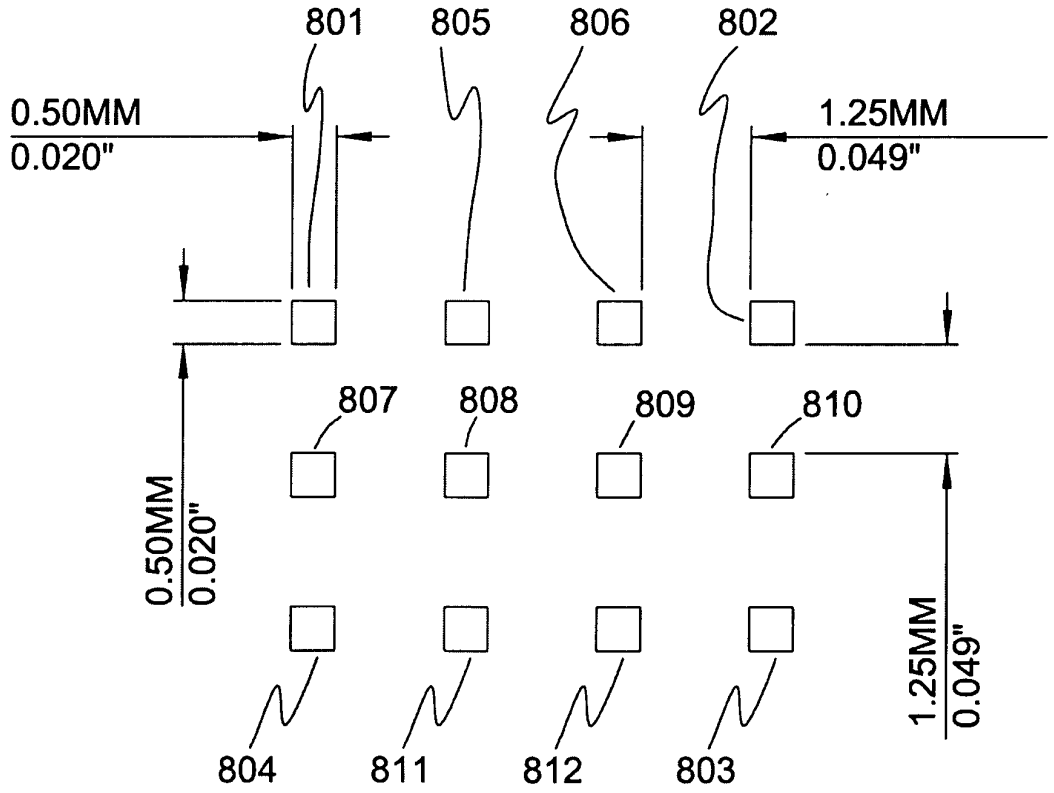

701
705
706
707
702
0.50MM
0.020"
1.25MM
0.049"
0.50MM
0.020"
703
708
709
710
704
1.25MM
0.049"

FIG. 8


801
805
806
802
0.50MM
0.020"
1.25MM
0.049"
807
808
809
810
0.50MM
0.020"
1.25MM
0.049"
804
811
812
803

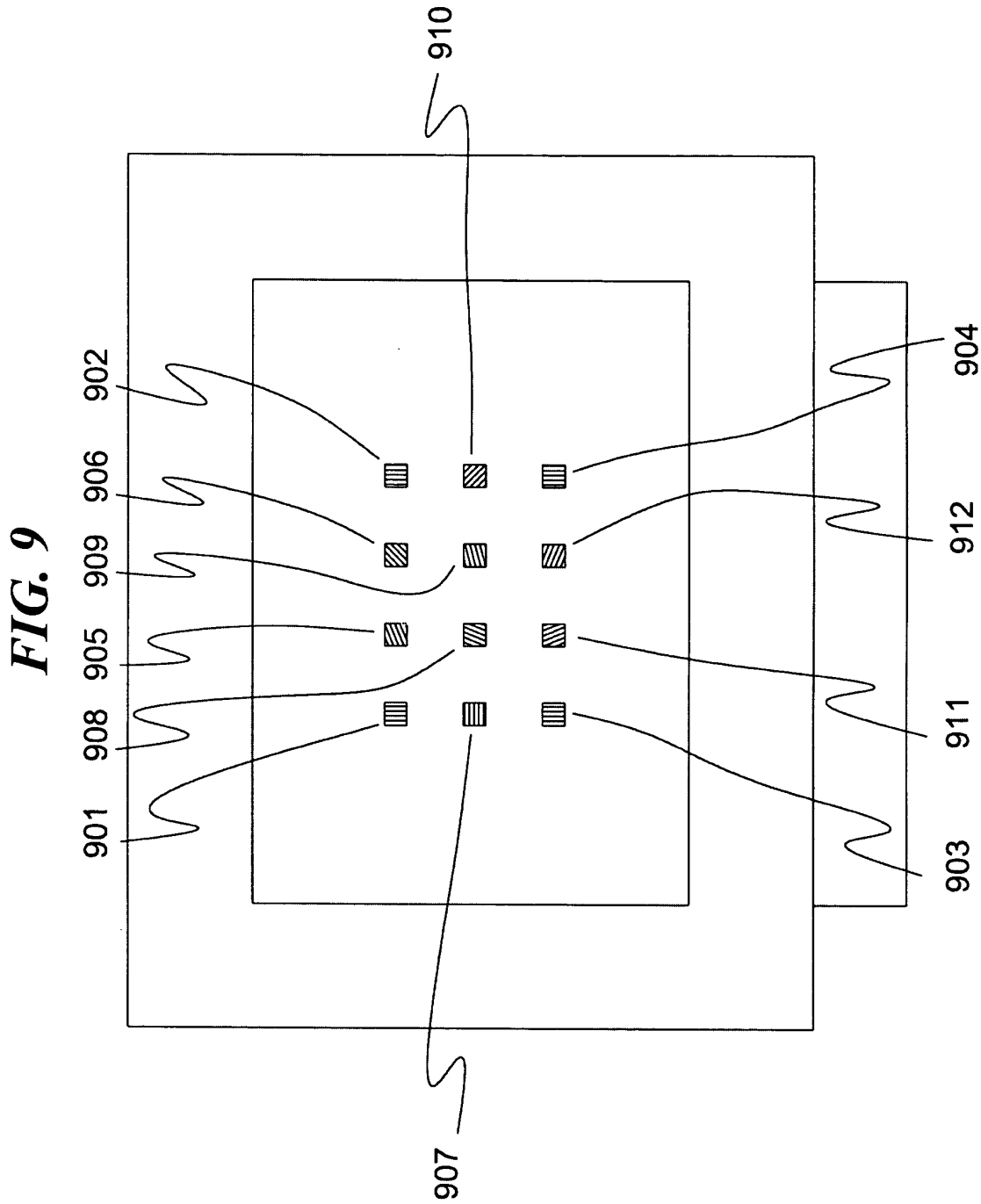


FIG. 9

FIG. 10

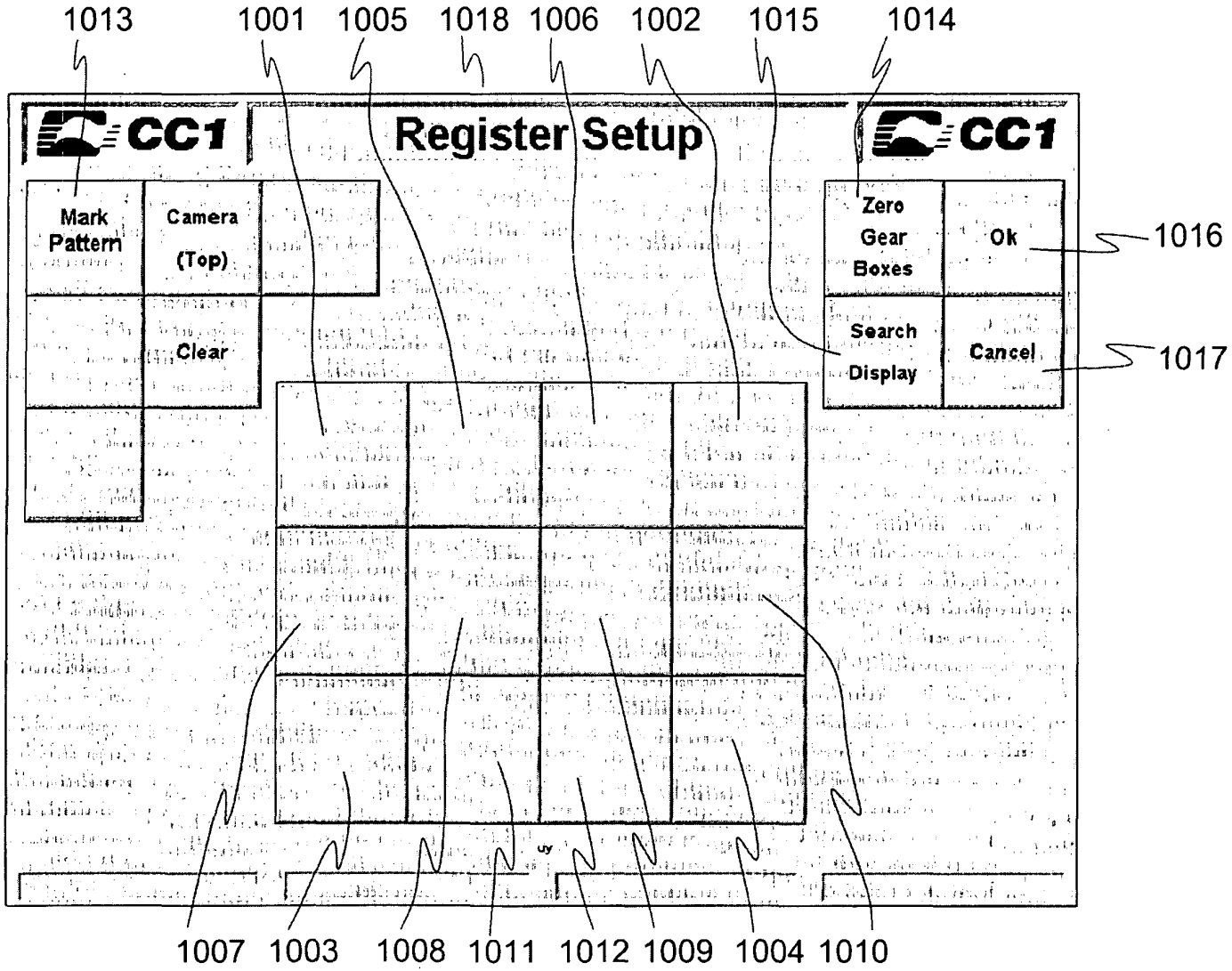

1013
1001
1005
1018
1006
1002
1015
1014
CC1
Register Setup
CC1
Mark Pattern
Camera (Top)
Clear
Zero Gear Boxes
Ok
1016
Search Display
Cancel
1017
1007
1003
1008
1011
1012
1009
1004
1010

FIG. 11

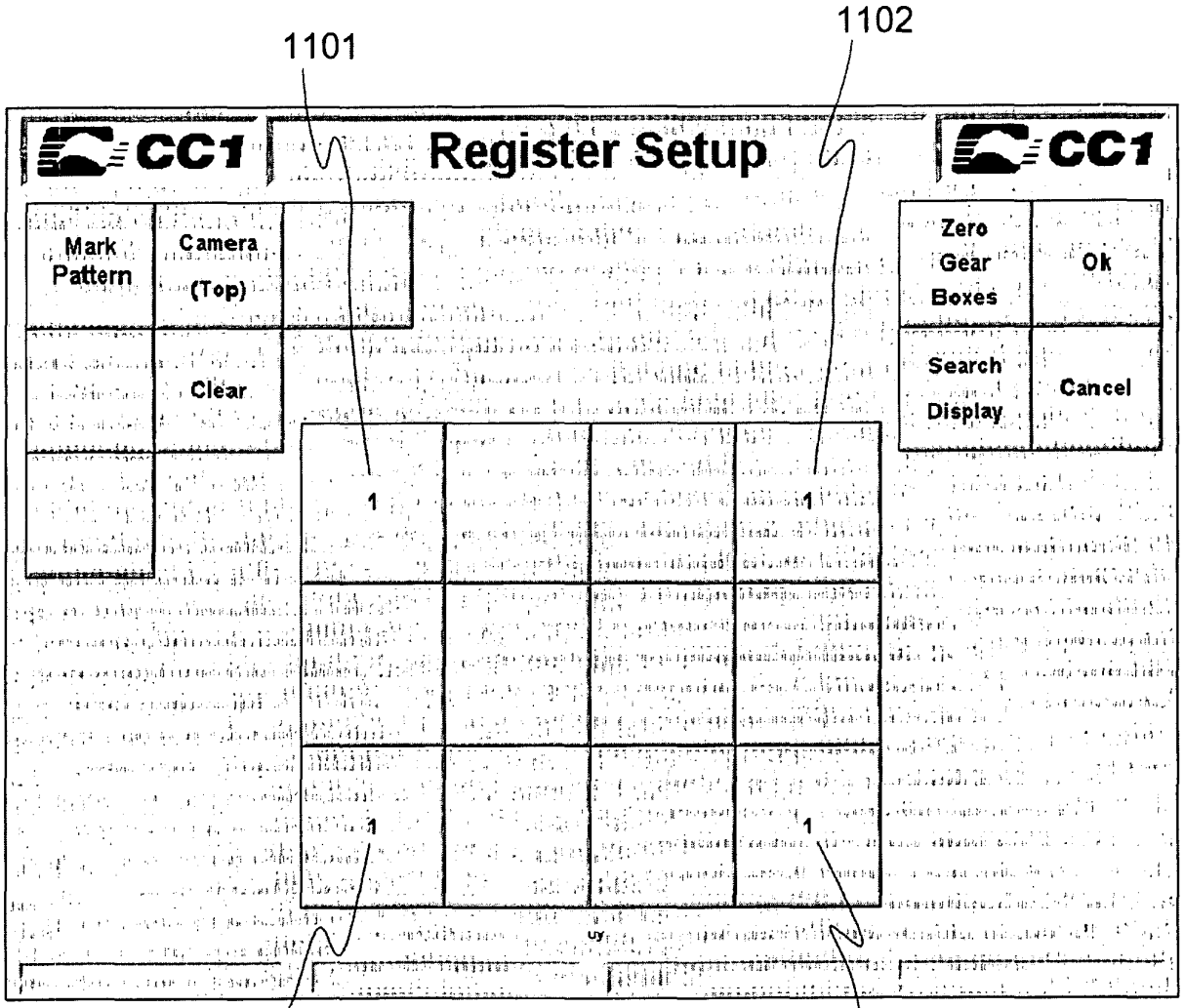

1101
1102
CC1
Register Setup
CC1
Mark Pattern
Camera (Top)
Clear
Zero Gear Boxes
Ok
Search Display
Cancel
1
1
1
1
1103
1104

FIG. 12

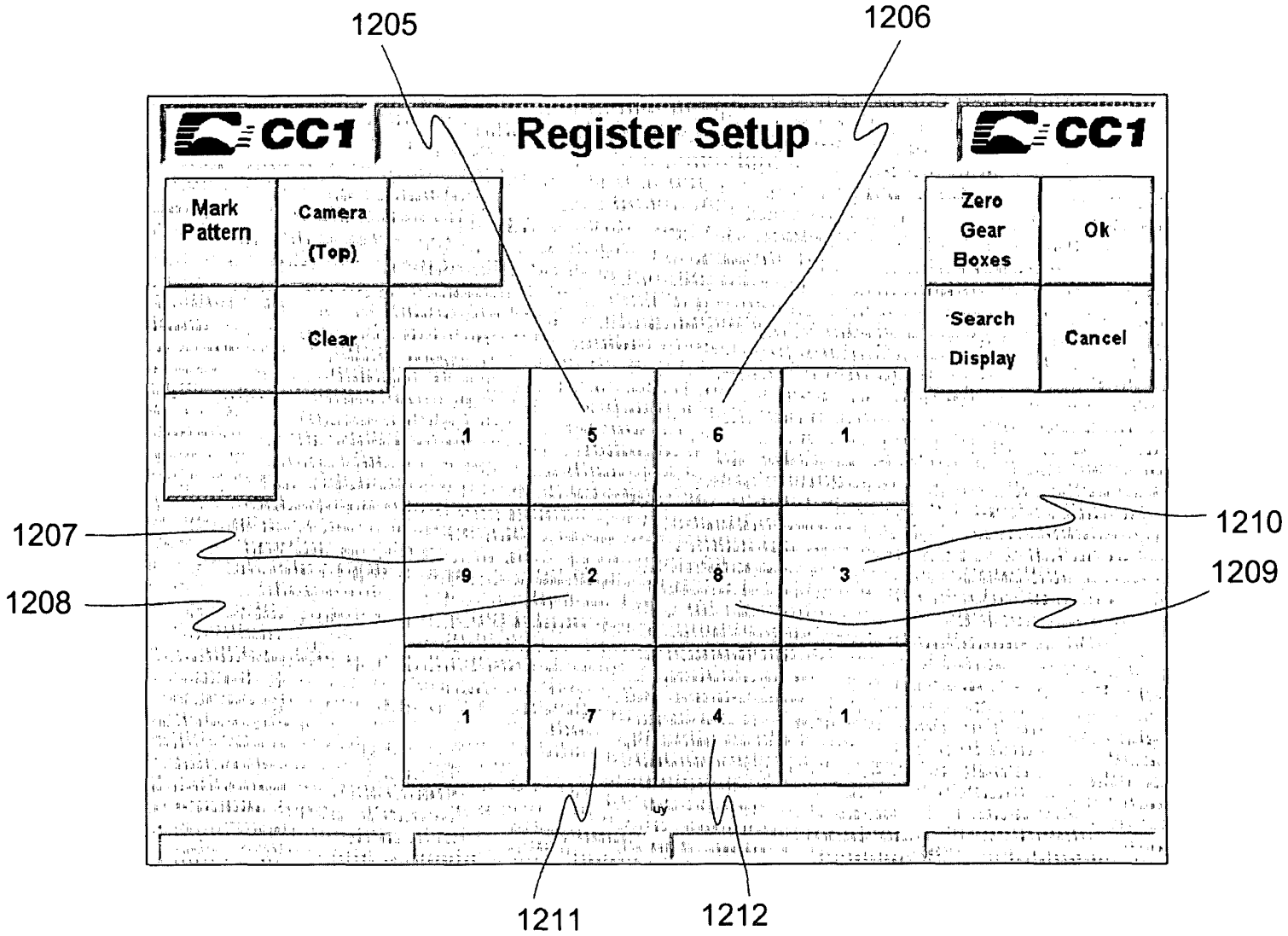

1205
1206
CC1
Register Setup
CC1
Mark Pattern
Camera (Top)
Clear
Zero Gear Boxes
Ok
Search Display
Cancel
1
5
6
1
9
2
8
3
1
7
4
1
1207
1208
1210
1209
1211
1212

FIG. 13

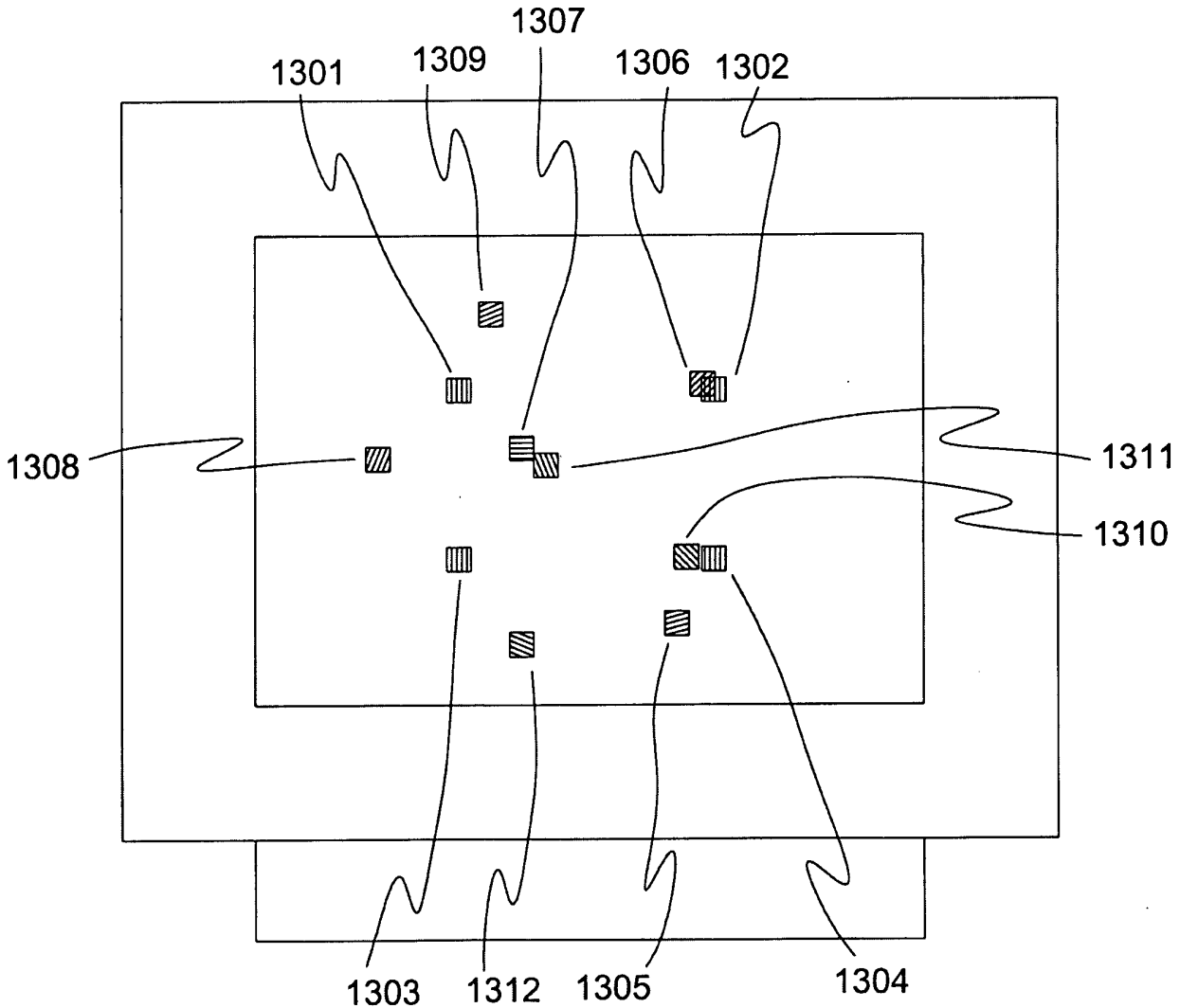


FIG. 14

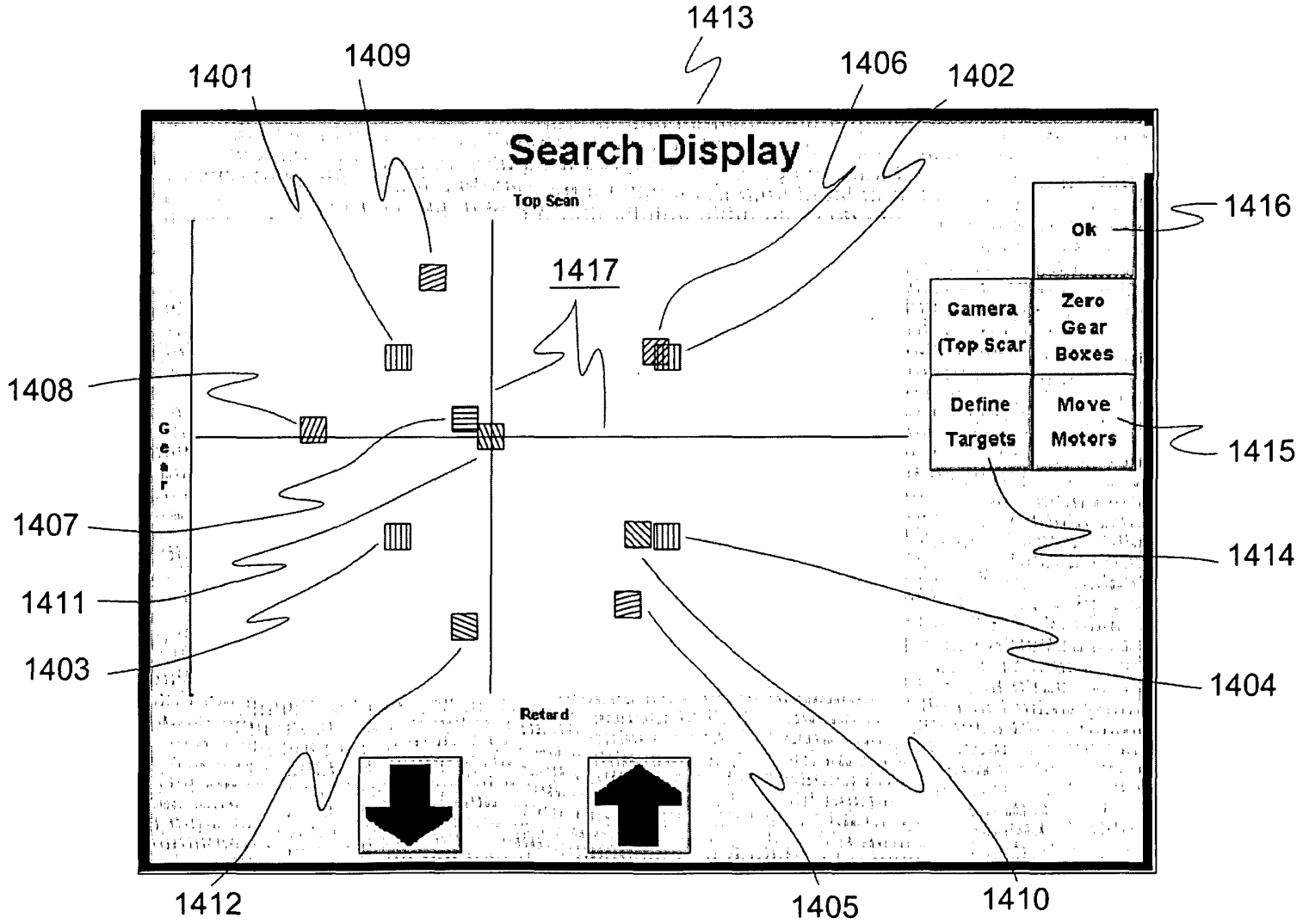
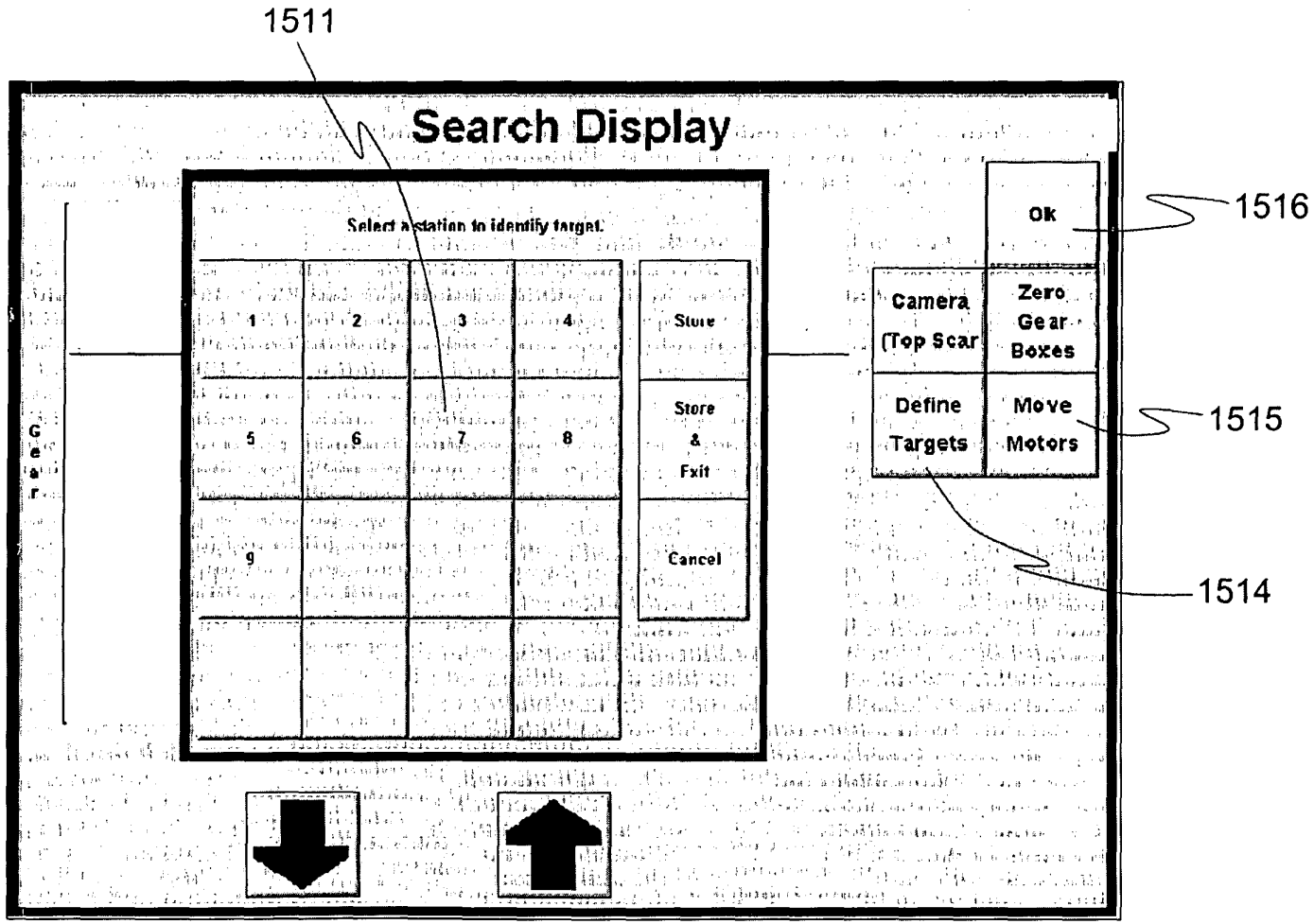

1413
1401
1409
1406
1402
Search Display
Top Scan
1417
Ok
1416
Camera (Top Scar
Zero Gear Boxes
Define Targets
Move Motors
1415
1408
Gear
1407
1414
1411
1403
1404
Retard
1412
1405
1410

FIG. 15


1511
Search Display
Select a station to identify target.
1
2
3
4
Store
5
6
7
8
Store & Exit
9
Cancel
Gear
Ok
1516
Camera (Top Scar
Zero Gear Boxes
Define Targets
Move Motors
1515
1514

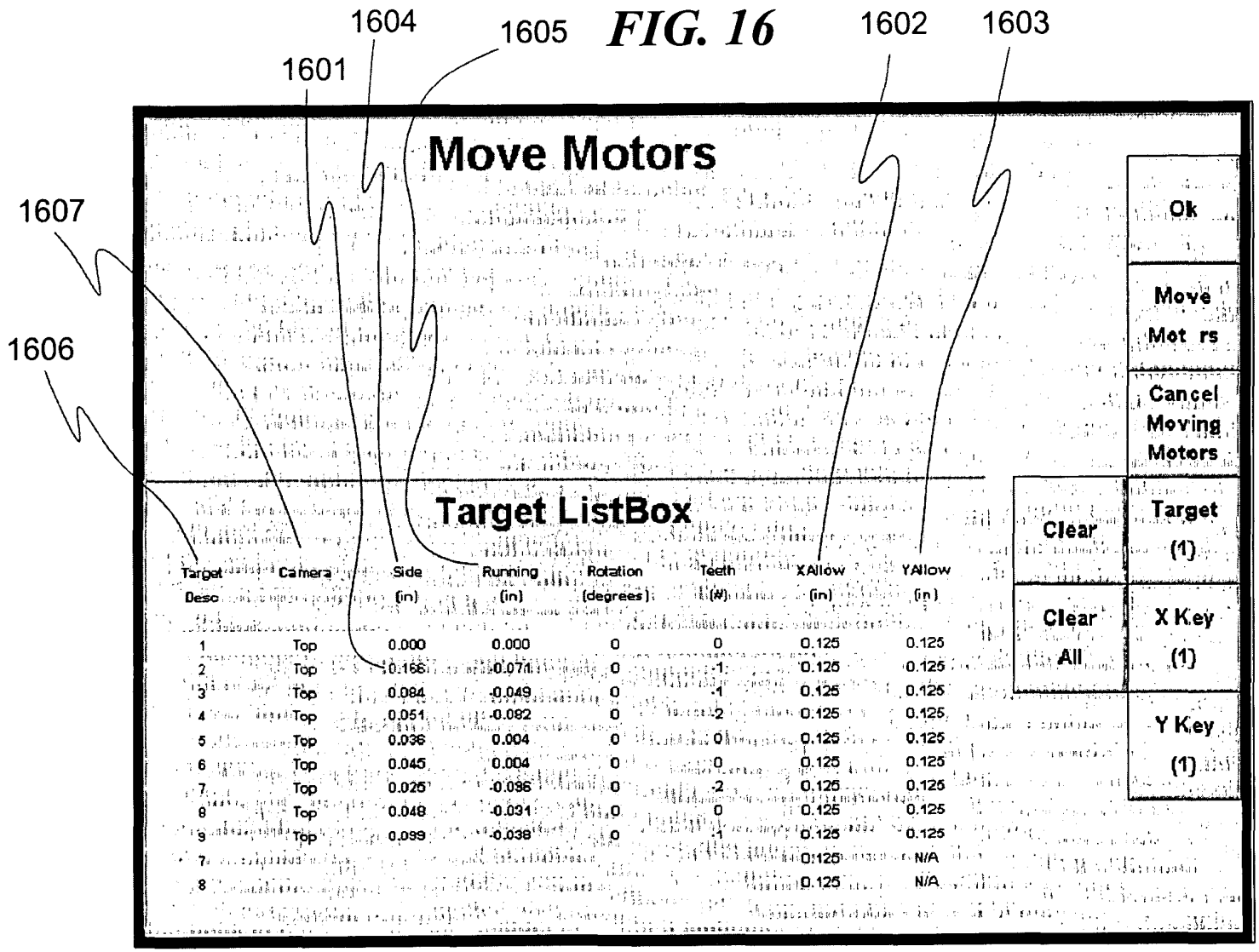

1604
1605
1601
1602
1603
1607
1606
Move Motors
Ok
Move Mot rs
Cancel Moving Motors
Target ListBox
Clear
Target (1)
Clear All
X Key (1)
Y Key (1)
Target Desc
Camera
Side (in)
Running (in)
Rotation (degrees)
Teeth (#)
XAllow (in)
YAllow (in)
1 Top 0.000 0.000 0 0 0.125 0.125
2 Top 0.168 0.071 0 -1 0.125 0.125
3 Top 0.084 -0.049 0 -1 0.125 0.125
4 Top 0.051 -0.082 0 -2 0.125 0.125
5 Top 0.036 0.004 0 0 0.125 0.125
6 Top 0.045 0.004 0 0 0.125 0.125
7 Top 0.025 -0.086 0 -2 0.125 0.125
8 Top 0.048 -0.031 0 0 0.125 0.125
9 Top 0.099 -0.038 0 -1 0.125 0.125
7 0.125 N/A
8 0.125 N/A

FIG. 16

FIG. 17

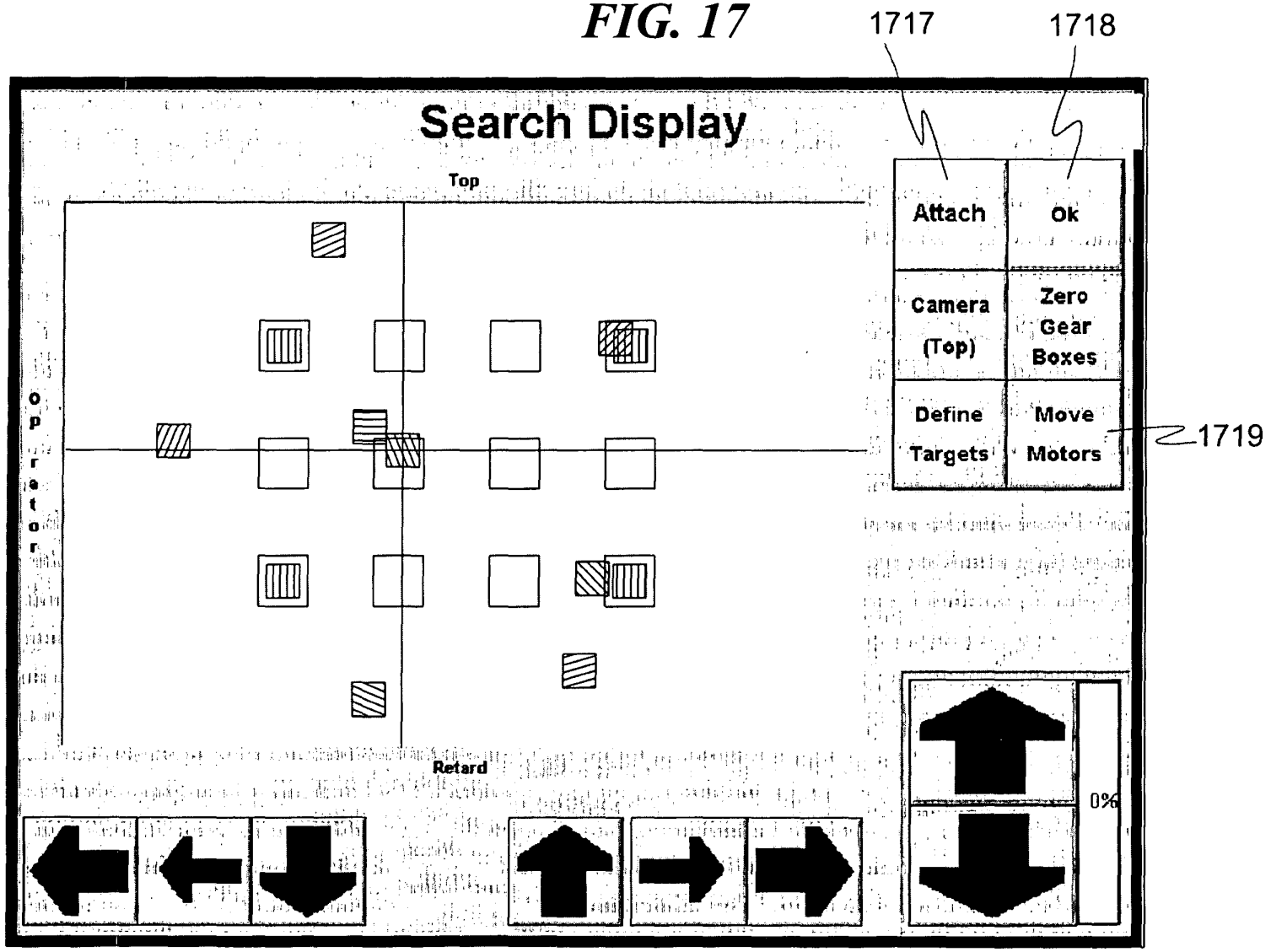

1717
1718
Search Display
Top
Operator
Retard
Attach
Ok
Camera (Top)
Zero Gear Boxes
Define Targets
Move Motors
1719
0%

FIG. 18

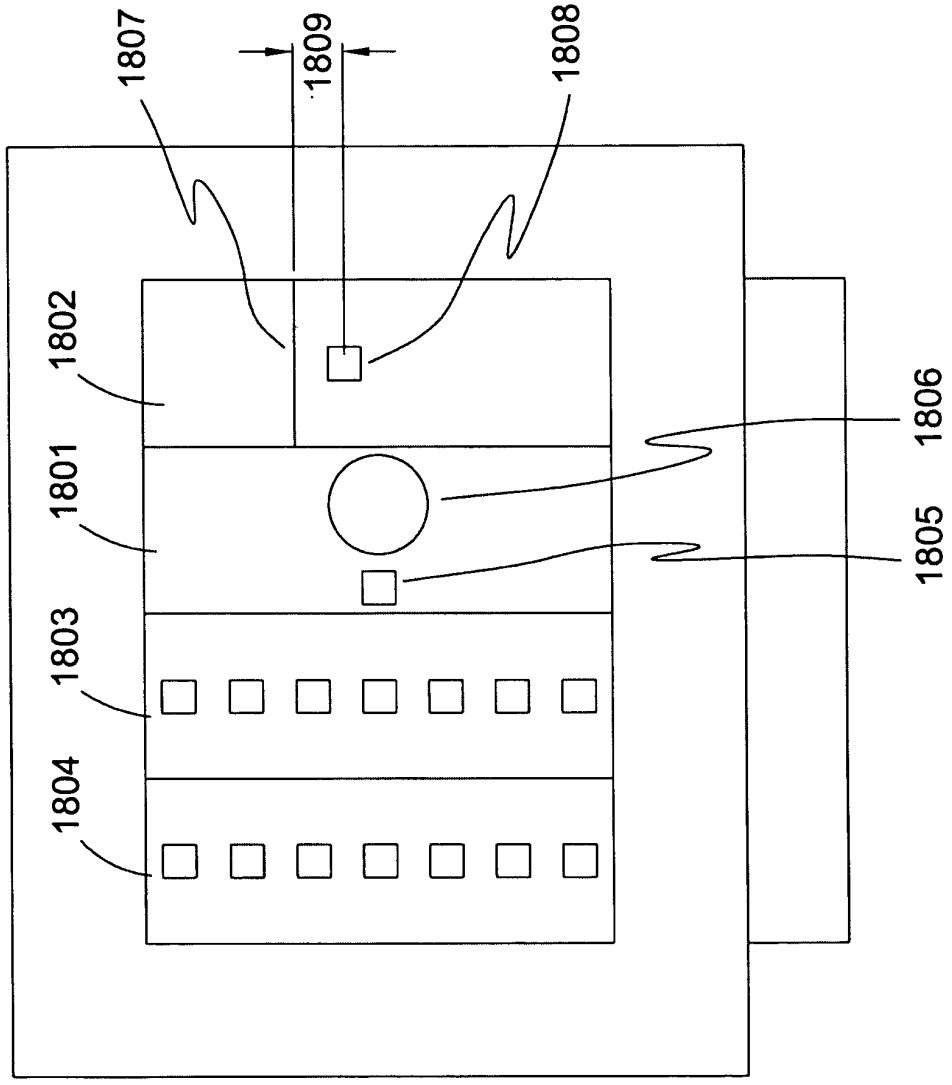


FIG. 19

Waste Savings Analysis Exemplary Newspaper Application 1900	
Customer Information	
Description	**Value**
1901 Circulation	50000
1902 Width (inches)	14.75
1903 Length (inches)	11.375
1904 Paper Pages Across Web Width	2
1905 Paper Pages Around Circumference	4
1906 # of Paper Pages/Cylinder Revolution	8
1907 Newsprint Cost (US$/Pound)	US$ 0.25
1908 Paper Weight (Pounds/Ream)	30
1909 Ink Cost (Percent of Paper Cost)	10%
1910 Make Ready Count / Day On Edition	3
1911 Days per Week	6
1912 Specials per Week	5
1913 Number of Paper Pages per Newspaper	36
1914 **Savings (Papers / Make Ready)**	**1000**
Calculations	
1915 Number of Webs	4.5
1916 Square Feet of Paper per Newspaper	41.95
1917 Weight/Paper (Pounds)	0.39
1918 Paper Cost per Newspaper	US$ 0.098
1919 Ink Cost per Newspaper	US$ 0.010
1920 Total Cost (per Newspaper)	US$ 0.108
1921 Cost per 1000 Papers	US$ 108.14
1922 Make Ready (per Week)	23
1923 **Savings per Week (Number of Papers)**	**23000**
1924 **Savings per Week (Tons of Newsprint)**	**4.5**
1925 **Savings per Year (Tons of Newsprint)**	**235**
1926 **Savings per Week (US$ paper & ink only)**	**US$ 2487**
1927 **Savings per Year (total US$)**	**US$ 129,336**

FIG. 20

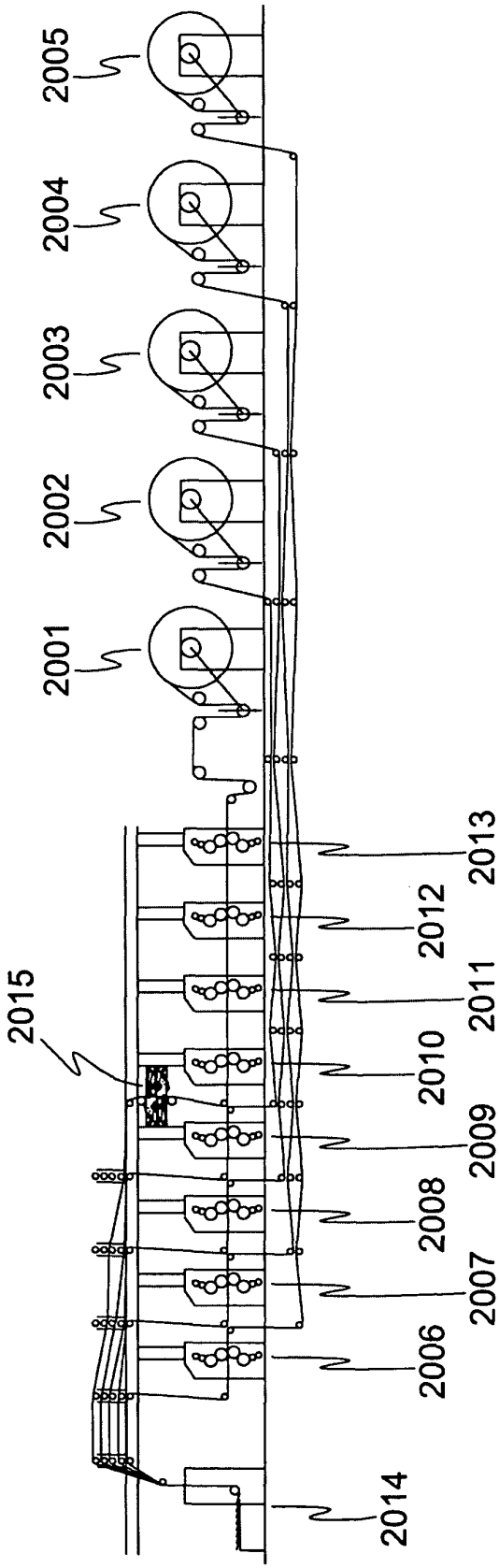

2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

FIG. 21

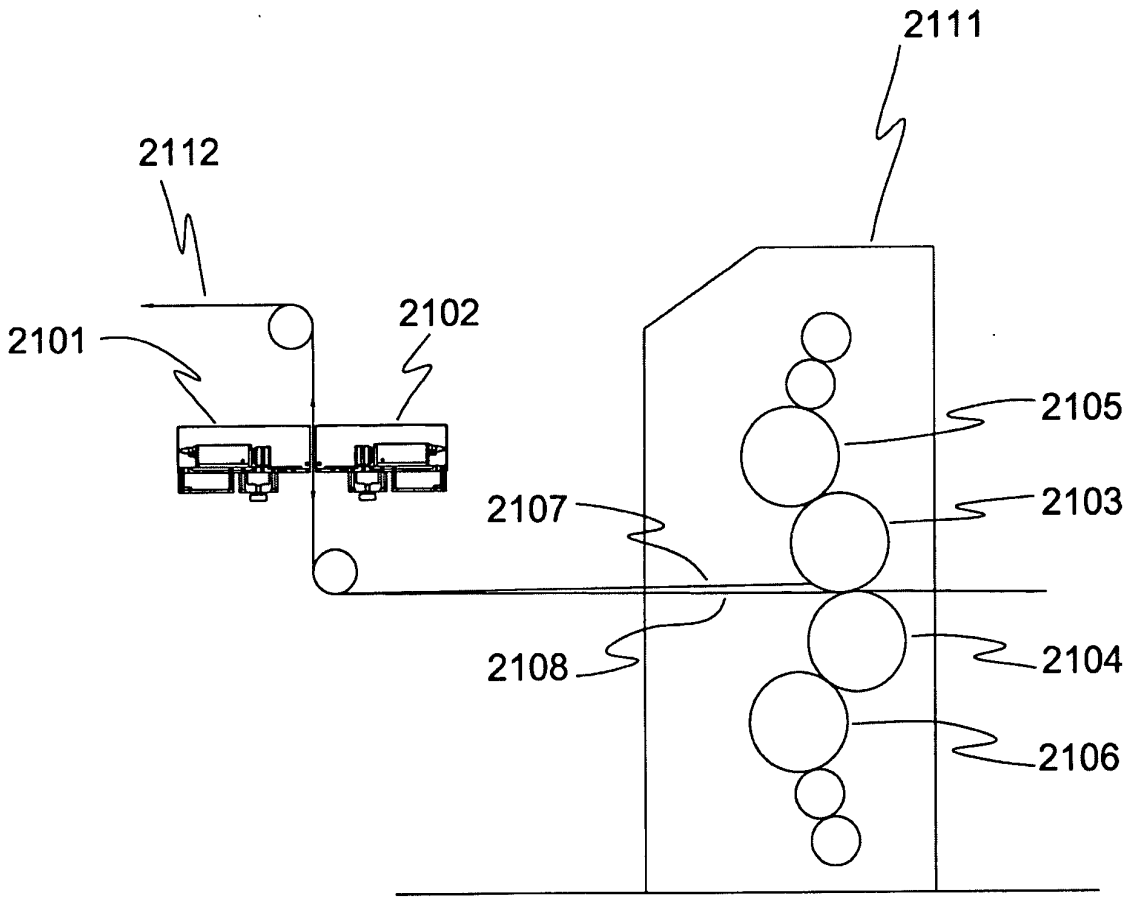


FIG. 22

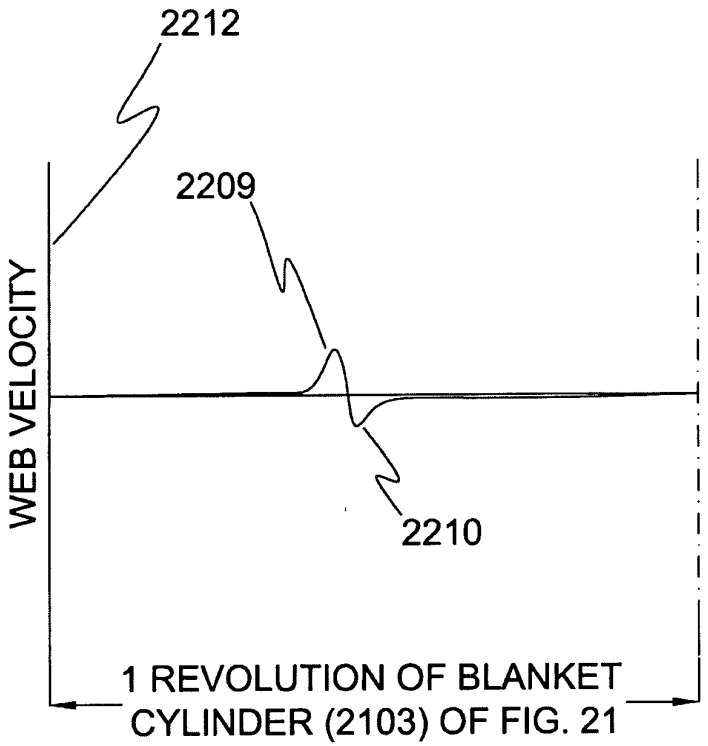

2212
2209
WEB VELOCITY
2210
1 REVOLUTION OF BLANKET
CYLINDER (2103) OF FIG. 21

FIG. 23

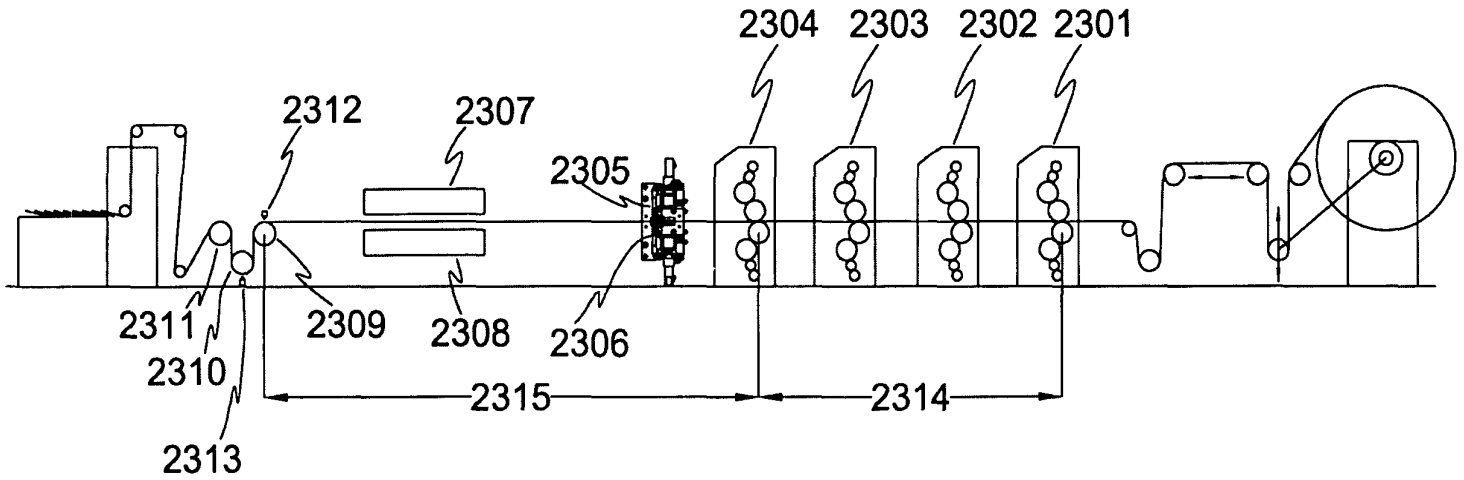

2304
2303
2302
2301
2312
2307
2305
2311
2309
2308
2306
2310
2315
2314
2313

FIG. 24

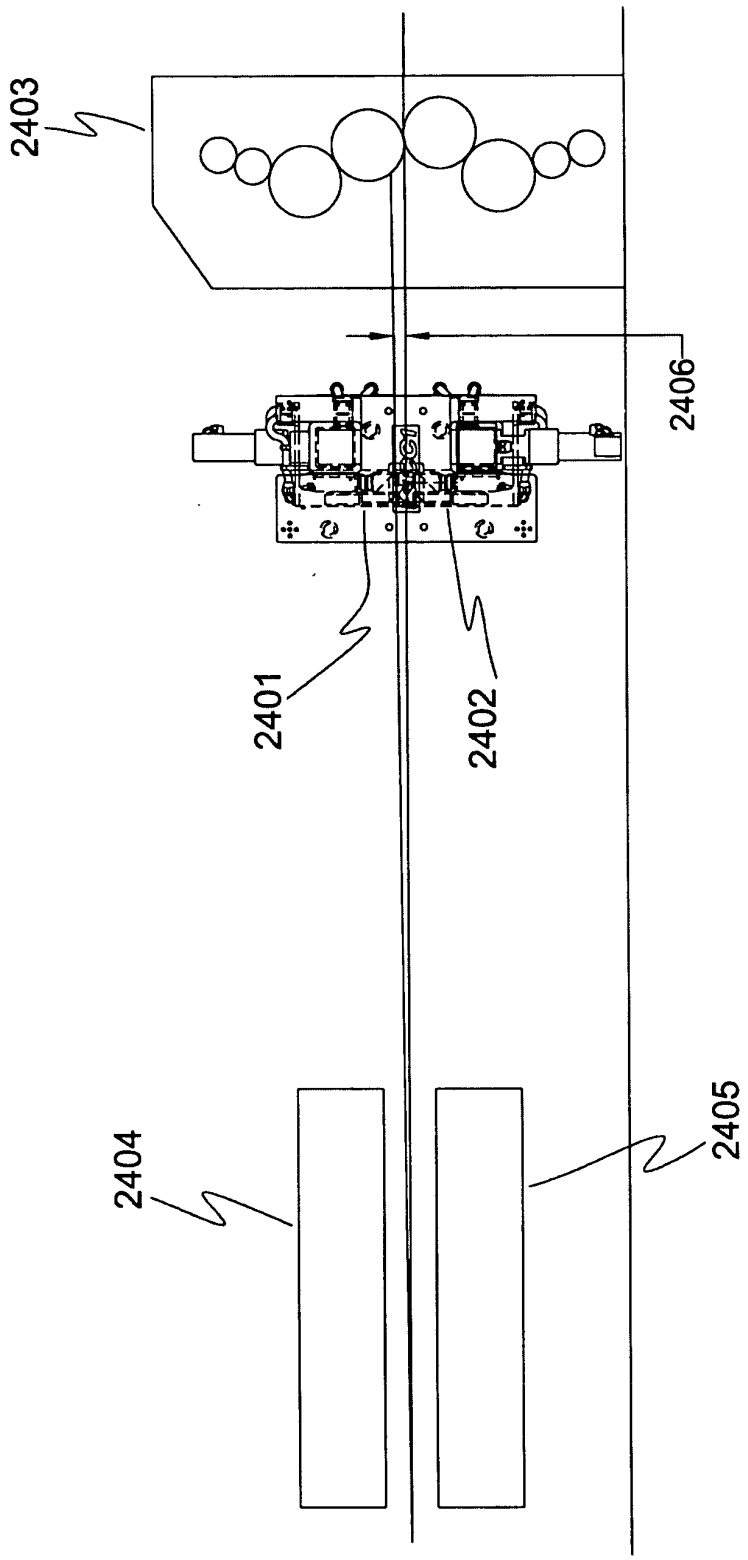
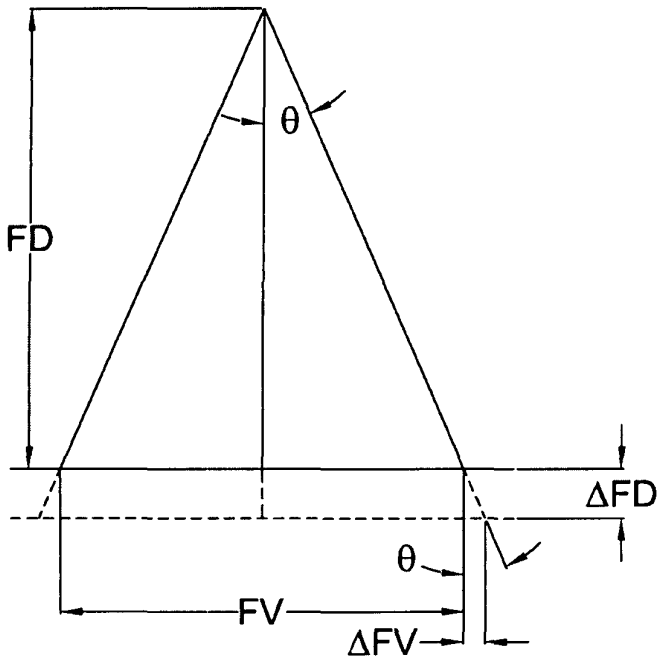


FIG. 25



2501 FV = FIELD OF VIEW
2502 FD = FOCAL DISTANCE
2503 ΔFD = CHANGE IN FOCAL DISTANCE
ΔFV = CHANGE IN FIELD OF VIEW
2504 ΔFV = ((ΔFD)(FV))/((FD)(2))

FOR
2505 ΔFD = 0.1"
2506 FD = 4.0"
2507 FV = 0.5"

2508 ΔFV = ((0.1)(0.5))/(4.0)(2) = 0.00625"

FIG. 26

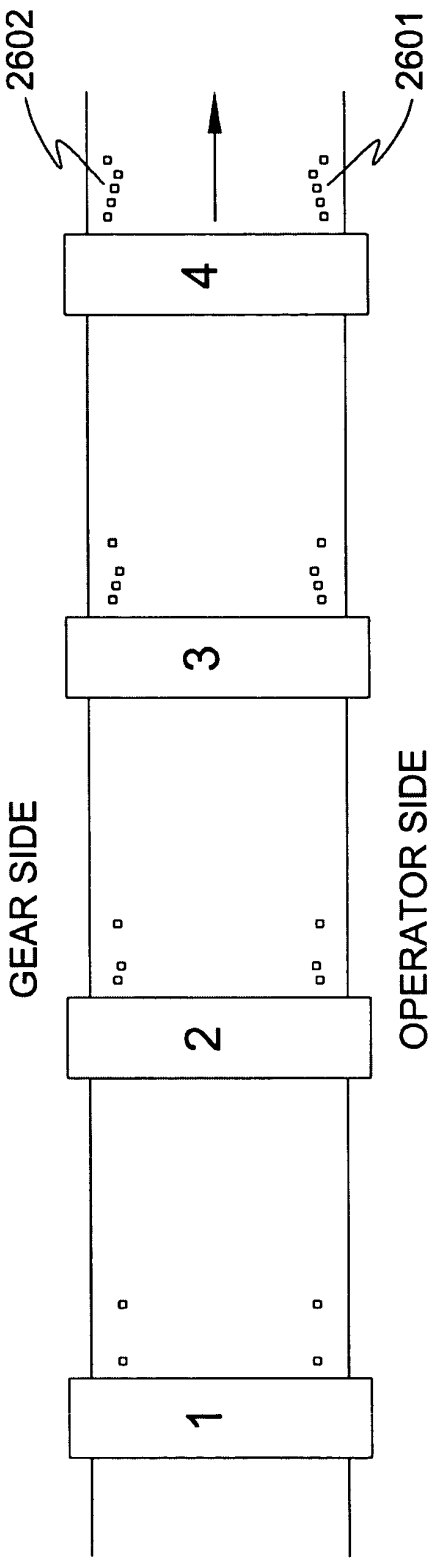


FIG. 27

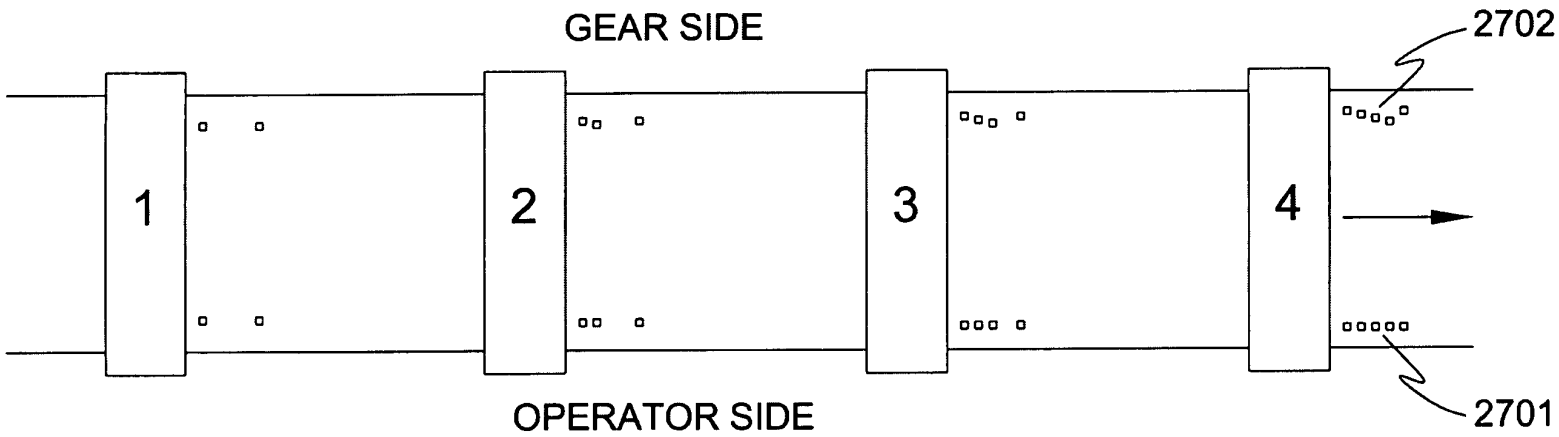


FIG. 28

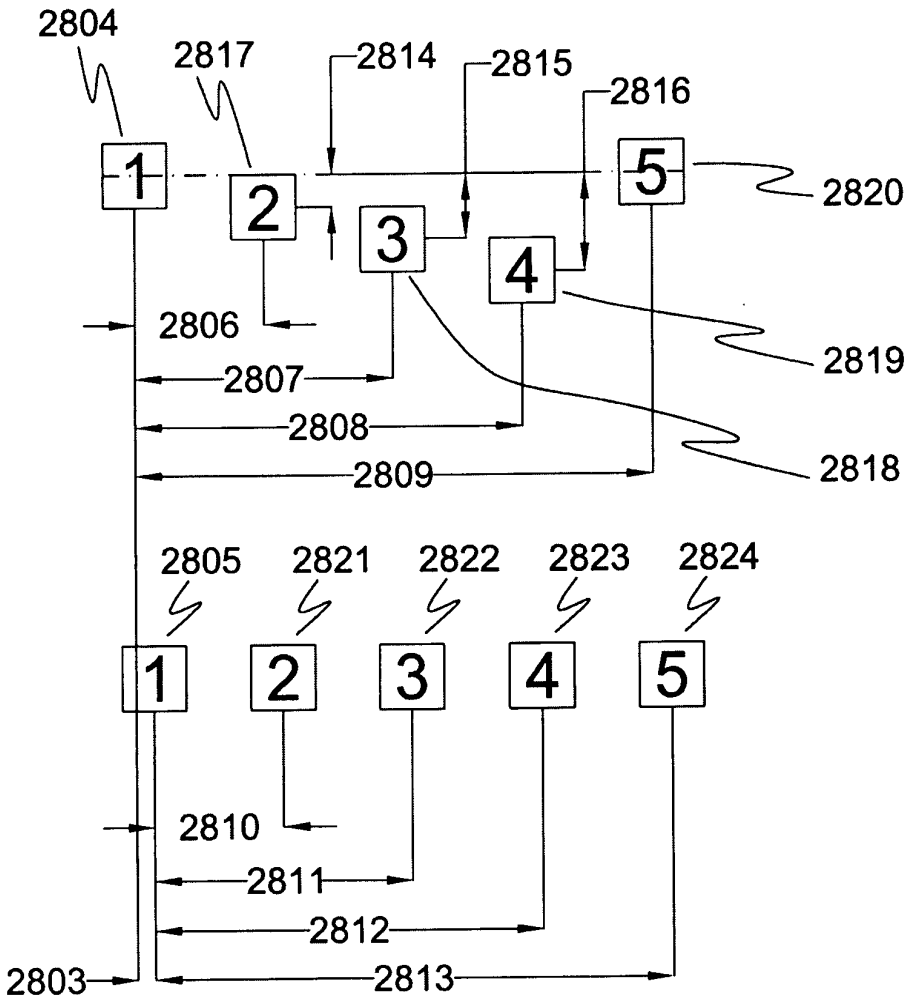

2804
2817
2814
2815
2816
1
2
3
4
5
2820
2806
2807
2808
2809
2819
2818
2805
2821
2822
2823
2824
1
2
3
4
5
2810
2811
2812
2803
2813

FIG. 29

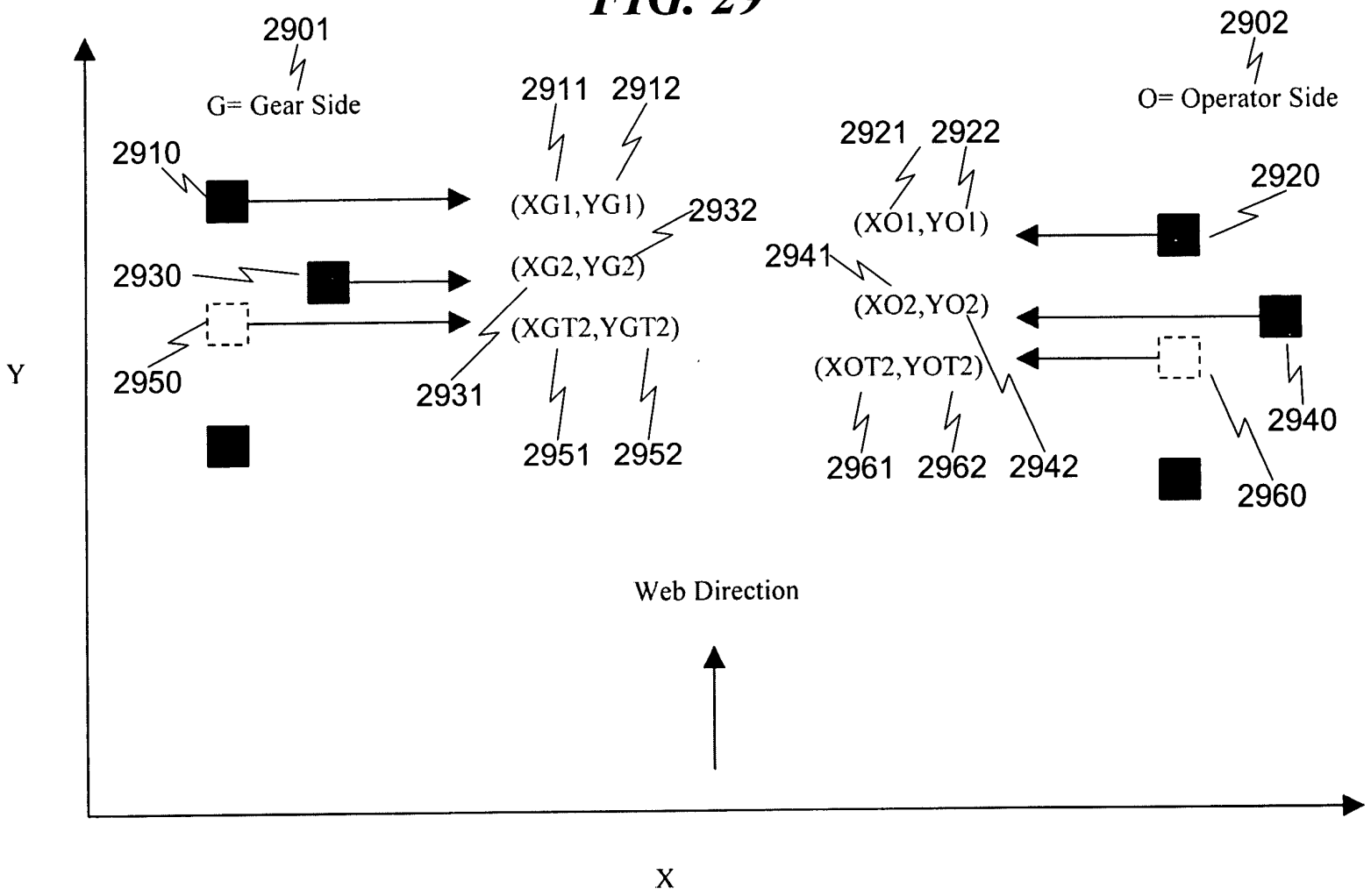

2901
G= Gear Side
2911
2912
2902
O= Operator Side
2910
(XG1,YG1)
2921
2922
2920
2932
(XO1,YO1)
2941
2930
(XG2,YG2)
(XO2,YO2)
(XGT2,YGT2)
(XOT2,YOT2)
2950
2931
2940
2951
2952
2961
2962
2942
2960
Y
Web Direction
X

FIG. 30

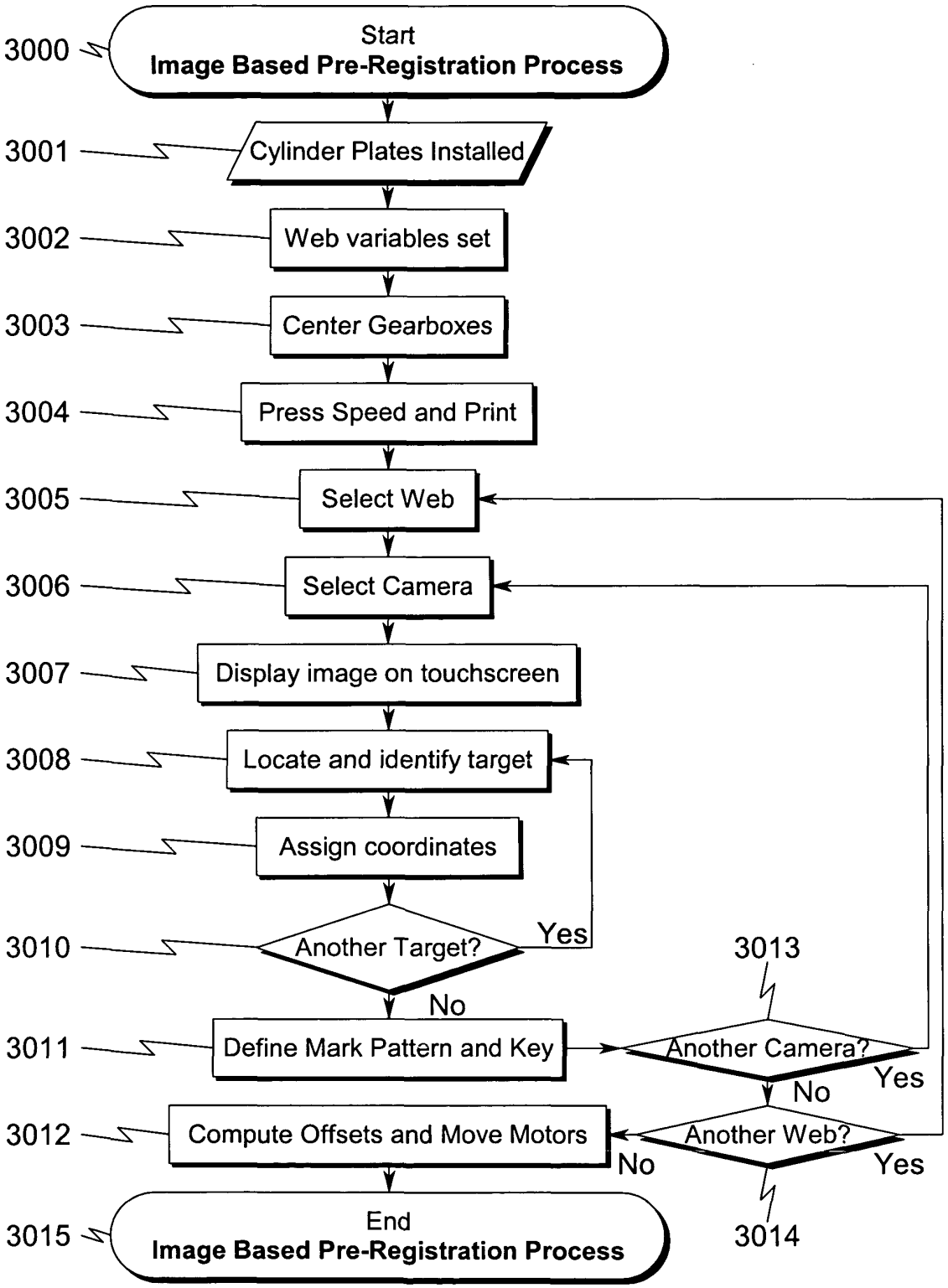

3000
Start
Image Based Pre-Registration Process
3001
Cylinder Plates Installed
3002
Web variables set
3003
Center Gearboxes
3004
Press Speed and Print
3005
Select Web
3006
Select Camera
3007
Display image on touchscreen
3008
Locate and identify target
3009
Assign coordinates
3010
Another Target?
Yes
No
3011
Define Mark Pattern and Key
3012
Compute Offsets and Move Motors
3013
Another Camera?
Yes
No
Another Web?
No
Yes
3014
3015
End
Image Based Pre-Registration Process

FIG. 31

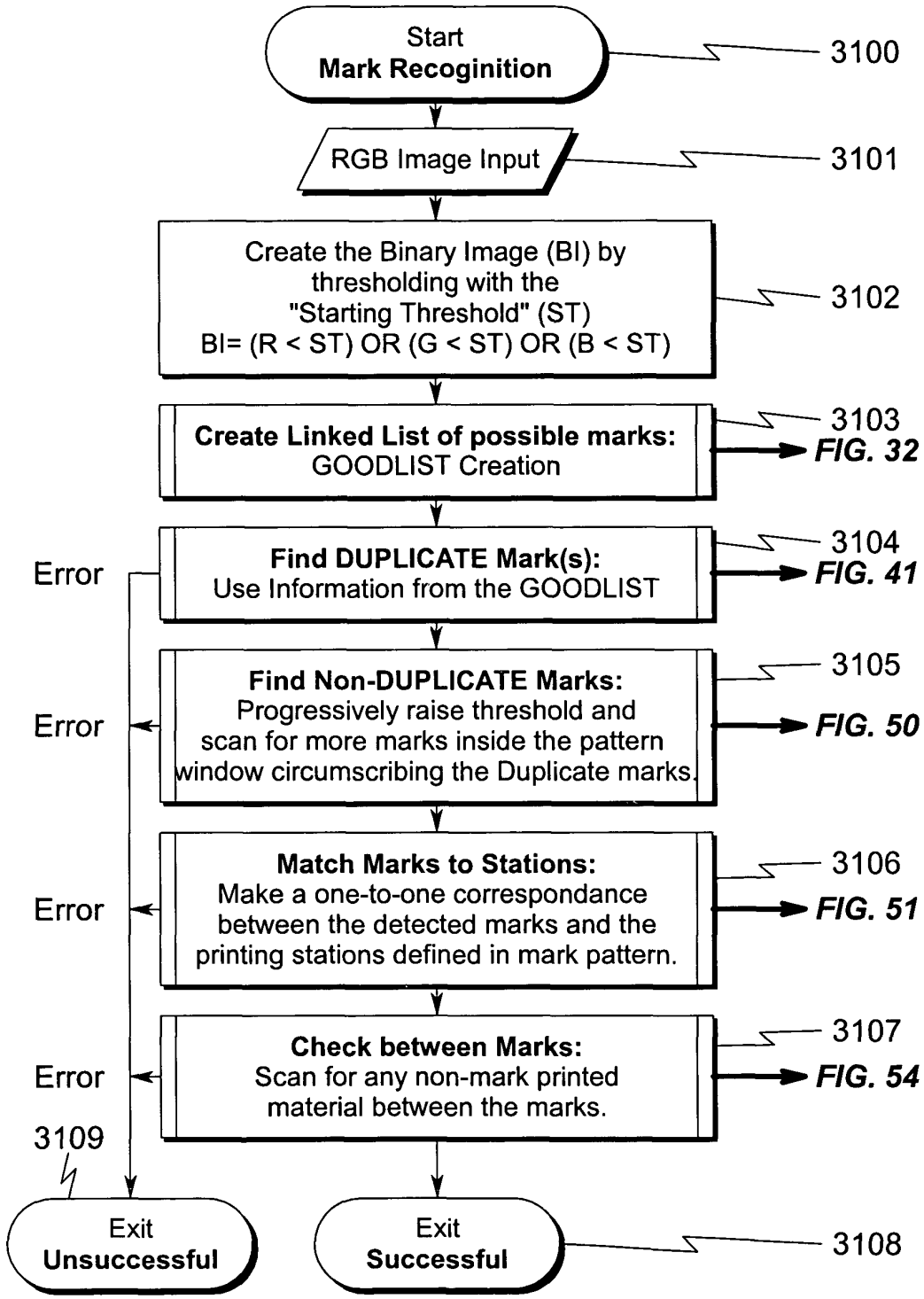

Start
Mark Recoginition
3100
RGB Image Input
3101
Create the Binary Image (BI) by thresholding with the "Starting Threshold" (ST)
BI= (R < ST) OR (G < ST) OR (B < ST)
3102
Create Linked List of possible marks:
GOODLIST Creation
3103
FIG. 32
Error
Find DUPLICATE Mark(s):
Use Information from the GOODLIST
3104
FIG. 41
Error
Find Non-DUPLICATE Marks:
Progressively raise threshold and scan for more marks inside the pattern window circumscribing the Duplicate marks.
3105
FIG. 50
Error
Match Marks to Stations:
Make a one-to-one correspondance between the detected marks and the printing stations defined in mark pattern.
3106
FIG. 51
Error
Check between Marks:
Scan for any non-mark printed material between the marks.
3107
FIG. 54
Error
3109
Exit
Unsuccessful
Exit
Successful
3108

FIG. 32

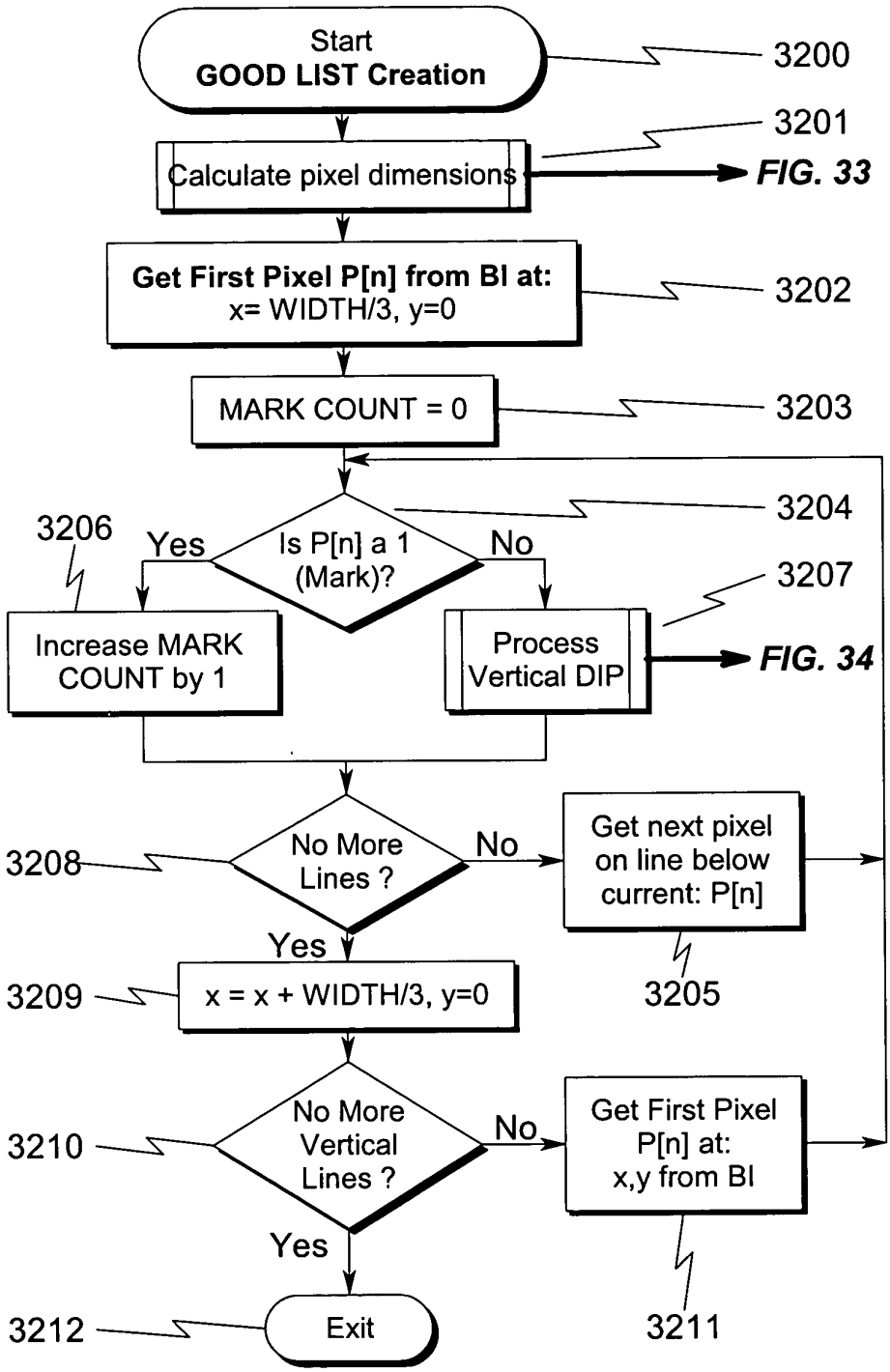

Start
GOOD LIST Creation
3200
3201
Calculate pixel dimensions
FIG. 33
Get First Pixel P[n] from BI at:
x= WIDTH/3, y=0
3202
MARK COUNT = 0
3203
3204
3206
Yes
Is P[n] a 1
(Mark)?
No
3207
Increase MARK
COUNT by 1
Process
Vertical DIP
FIG. 34
3208
No More
Lines ?
No
Get next pixel
on line below
current: P[n]
Yes
3209
x = x + WIDTH/3, y=0
3205
3210
No More
Vertical
Lines ?
No
Get First Pixel
P[n] at:
x,y from BI
Yes
3212
Exit
3211

FIG. 33

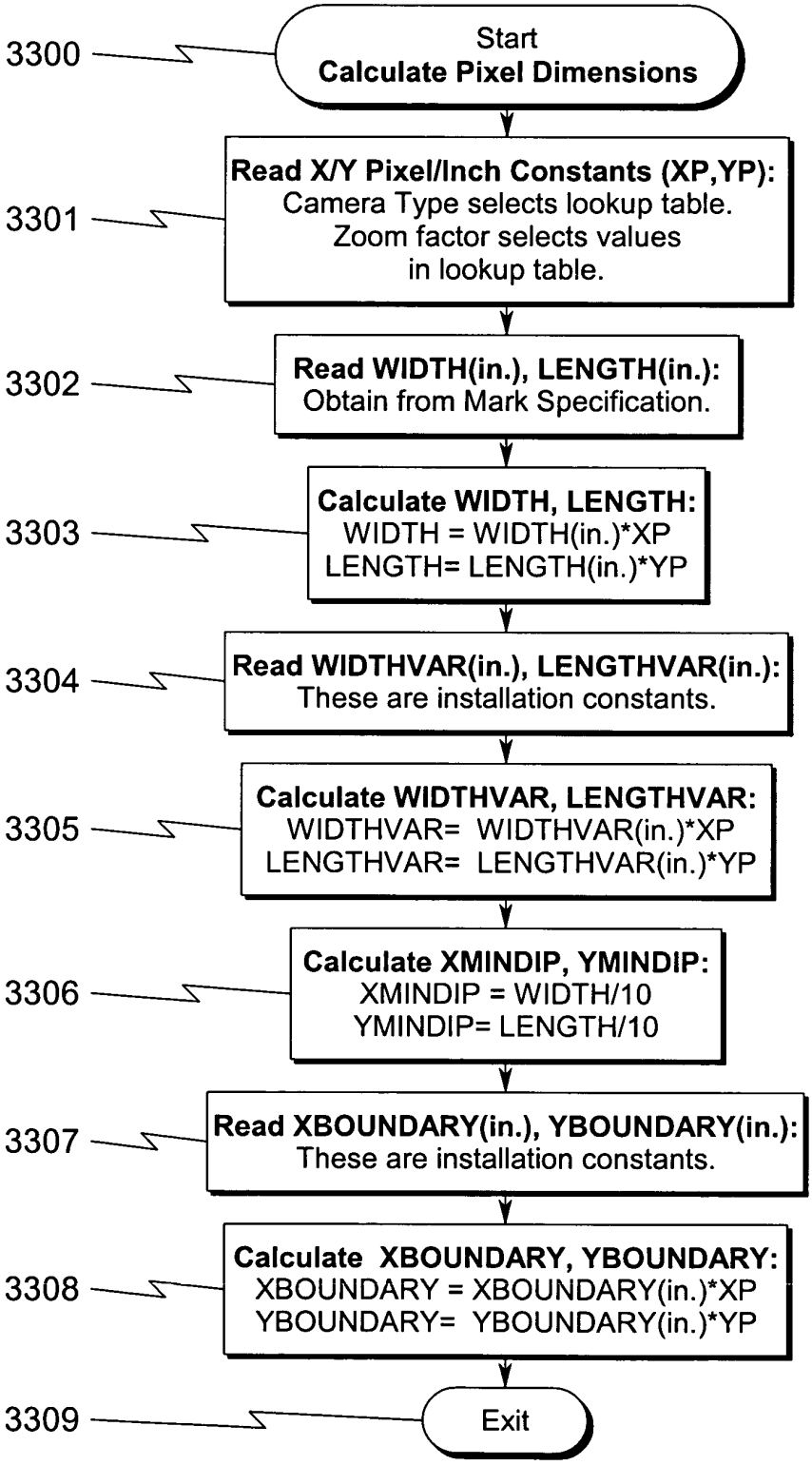

3300
Start
Calculate Pixel Dimensions
3301
Read X/Y Pixel/Inch Constants (XP,YP):
Camera Type selects lookup table.
Zoom factor selects values
in lookup table.
3302
Read WIDTH(in.), LENGTH(in.):
Obtain from Mark Specification.
3303
Calculate WIDTH, LENGTH:
WIDTH = WIDTH(in.)*XP
LENGTH= LENGTH(in.)*YP
3304
Read WIDTHVAR(in.), LENGTHVAR(in.):
These are installation constants.
3305
Calculate WIDTHVAR, LENGTHVAR:
WIDTHVAR= WIDTHVAR(in.)*XP
LENGTHVAR= LENGTHVAR(in.)*YP
3306
Calculate XMINDIP, YMINDIP:
XMINDIP = WIDTH/10
YMINDIP= LENGTH/10
3307
Read XBOUNDARY(in.), YBOUNDARY(in.):
These are installation constants.
3308
Calculate XBOUNDARY, YBOUNDARY:
XBOUNDARY = XBOUNDARY(in.)*XP
YBOUNDARY= YBOUNDARY(in.)*YP
3309
Exit

FIG. 34

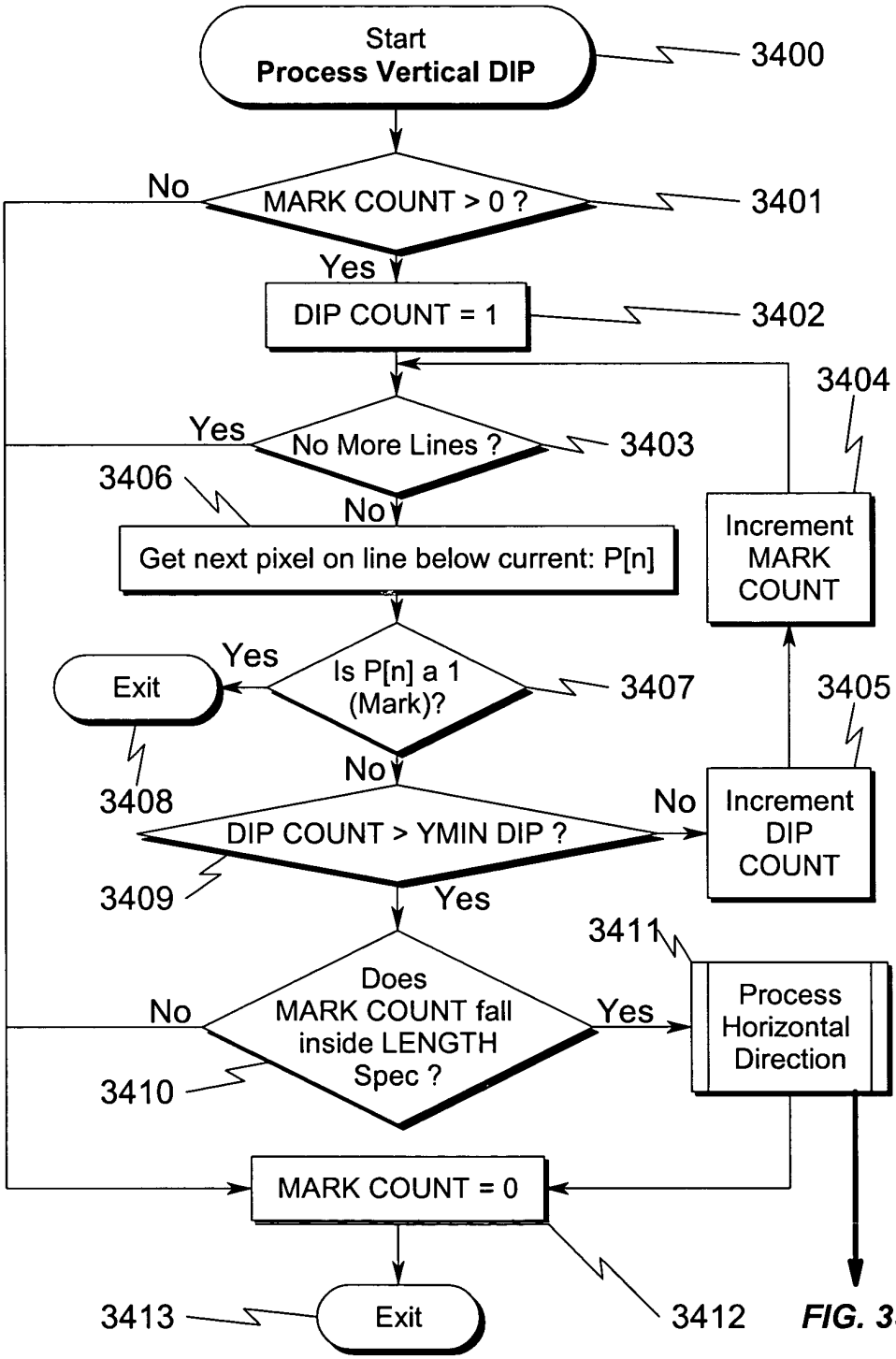

Start
Process Vertical DIP
3400
MARK COUNT > 0 ?
No
3401
Yes
DIP COUNT = 1
3402
3404
No More Lines ?
Yes
3403
3406
No
Get next pixel on line below current: P[n]
Increment MARK COUNT
Is P[n] a 1 (Mark)?
Yes
Exit
3407
3405
No
3408
DIP COUNT > YMIN DIP ?
No
Increment DIP COUNT
3409
Yes
3411
Does MARK COUNT fall inside LENGTH Spec ?
No
Yes
Process Horizontal Direction
3410
MARK COUNT = 0
3413
Exit
3412

FIG. 35

FIG. 35

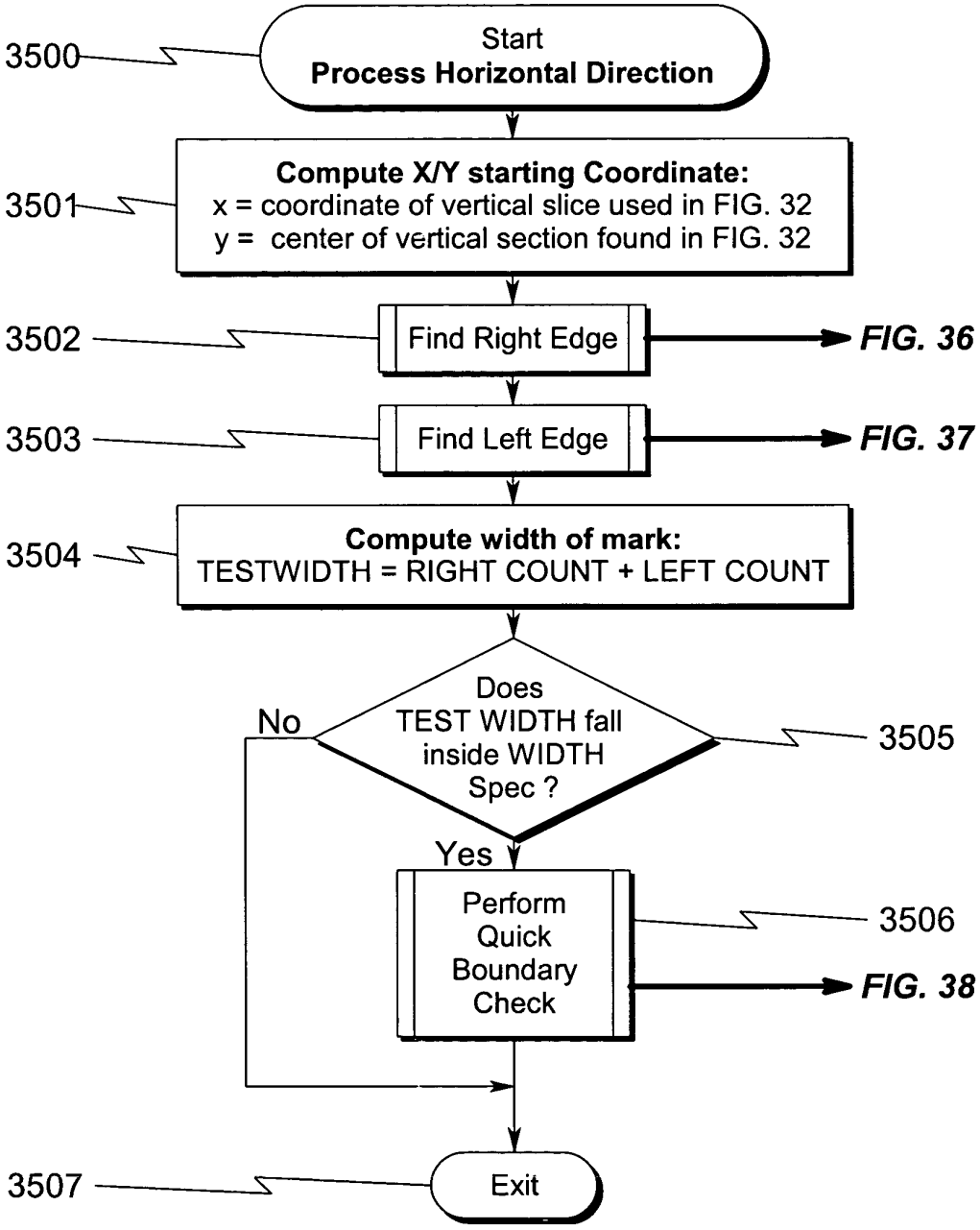

3500
Start
Process Horizontal Direction
3501
Compute X/Y starting Coordinate:
x = coordinate of vertical slice used in FIG. 32
y = center of vertical section found in FIG. 32
3502
Find Right Edge
FIG. 36
3503
Find Left Edge
FIG. 37
3504
Compute width of mark:
TESTWIDTH = RIGHT COUNT + LEFT COUNT
Does TEST WIDTH fall inside WIDTH Spec ?
No
3505
Yes
Perform Quick Boundary Check
3506
FIG. 38
3507
Exit

FIG. 36

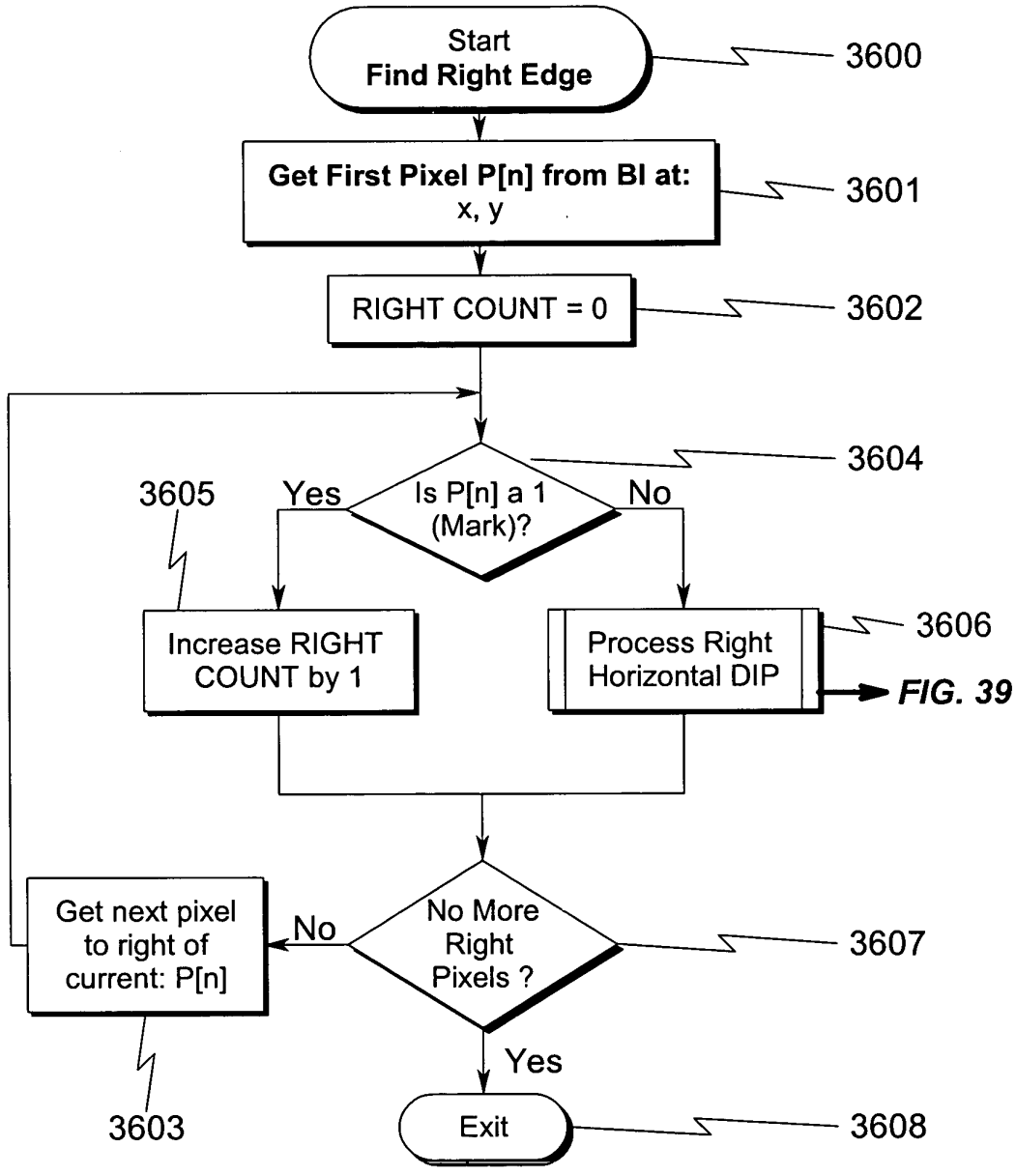

Start
Find Right Edge
3600
Get First Pixel P[n] from BI at:
x, y
3601
RIGHT COUNT = 0
3602
3604
Is P[n] a 1
(Mark)?
Yes
No
3605
Increase RIGHT
COUNT by 1
Process Right
Horizontal DIP
3606
FIG. 39
No More
Right
Pixels ?
3607
No
Get next pixel
to right of
current: P[n]
3603
Yes
Exit
3608

FIG. 37

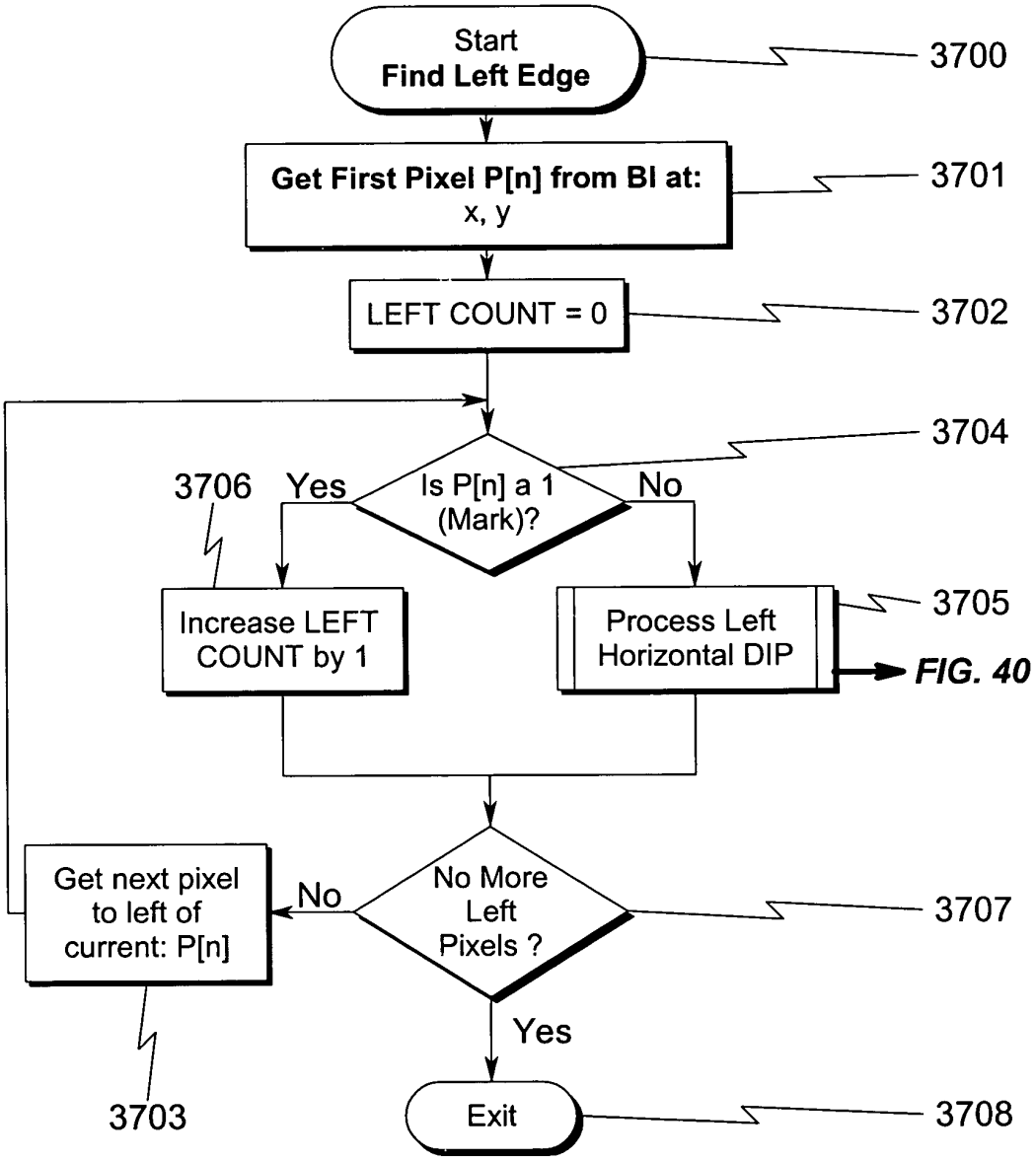

Start
Find Left Edge
3700
Get First Pixel P[n] from BI at:
x, y
3701
LEFT COUNT = 0
3702
3704
3706
Yes
Is P[n] a 1
(Mark)?
No
Increase LEFT
COUNT by 1
Process Left
Horizontal DIP
3705
FIG. 40
Get next pixel
to left of
current: P[n]
No
No More
Left
Pixels ?
3707
Yes
3703
Exit
3708

FIG. 38

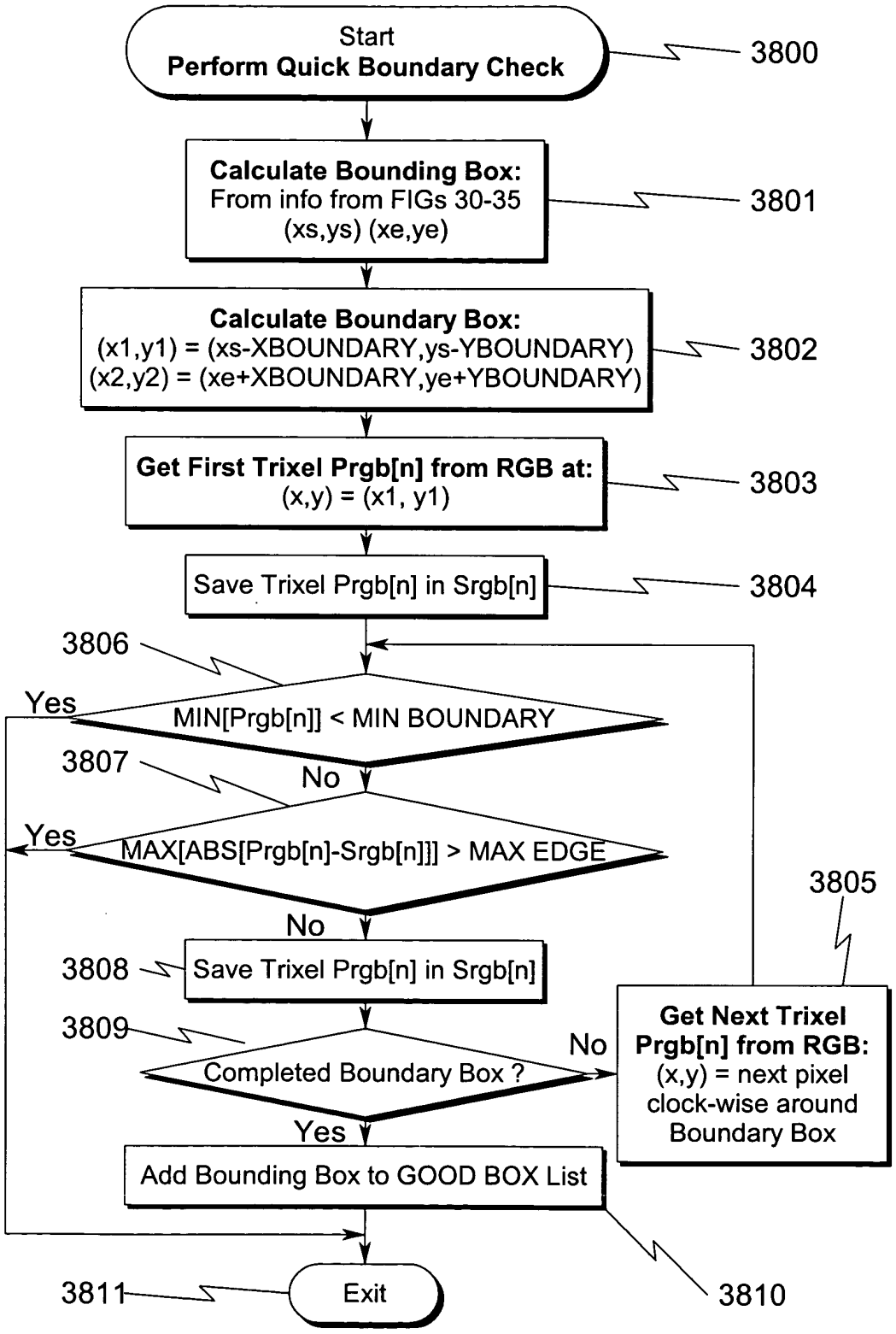

Start
Perform Quick Boundary Check
3800
Calculate Bounding Box:
From info from FIGs 30-35
(xs,ys) (xe,ye)
3801
Calculate Boundary Box:
(x1,y1) = (xs-XBOUNDARY,ys-YBOUNDARY)
(x2,y2) = (xe+XBOUNDARY,ye+YBOUNDARY)
3802
Get First Trixel Prgb[n] from RGB at:
(x,y) = (x1, y1)
3803
Save Trixel Prgb[n] in Srgb[n]
3804
3806
Yes
MIN[Prgb[n]] < MIN BOUNDARY
3807
No
Yes
MAX[ABS[Prgb[n]-Srgb[n]]] > MAX EDGE
No
3808
Save Trixel Prgb[n] in Srgb[n]
3809
Completed Boundary Box ?
No
Yes
Add Bounding Box to GOOD BOX List
3805
Get Next Trixel Prgb[n] from RGB:
(x,y) = next pixel clock-wise around Boundary Box
3810
3811
Exit

FIG. 39

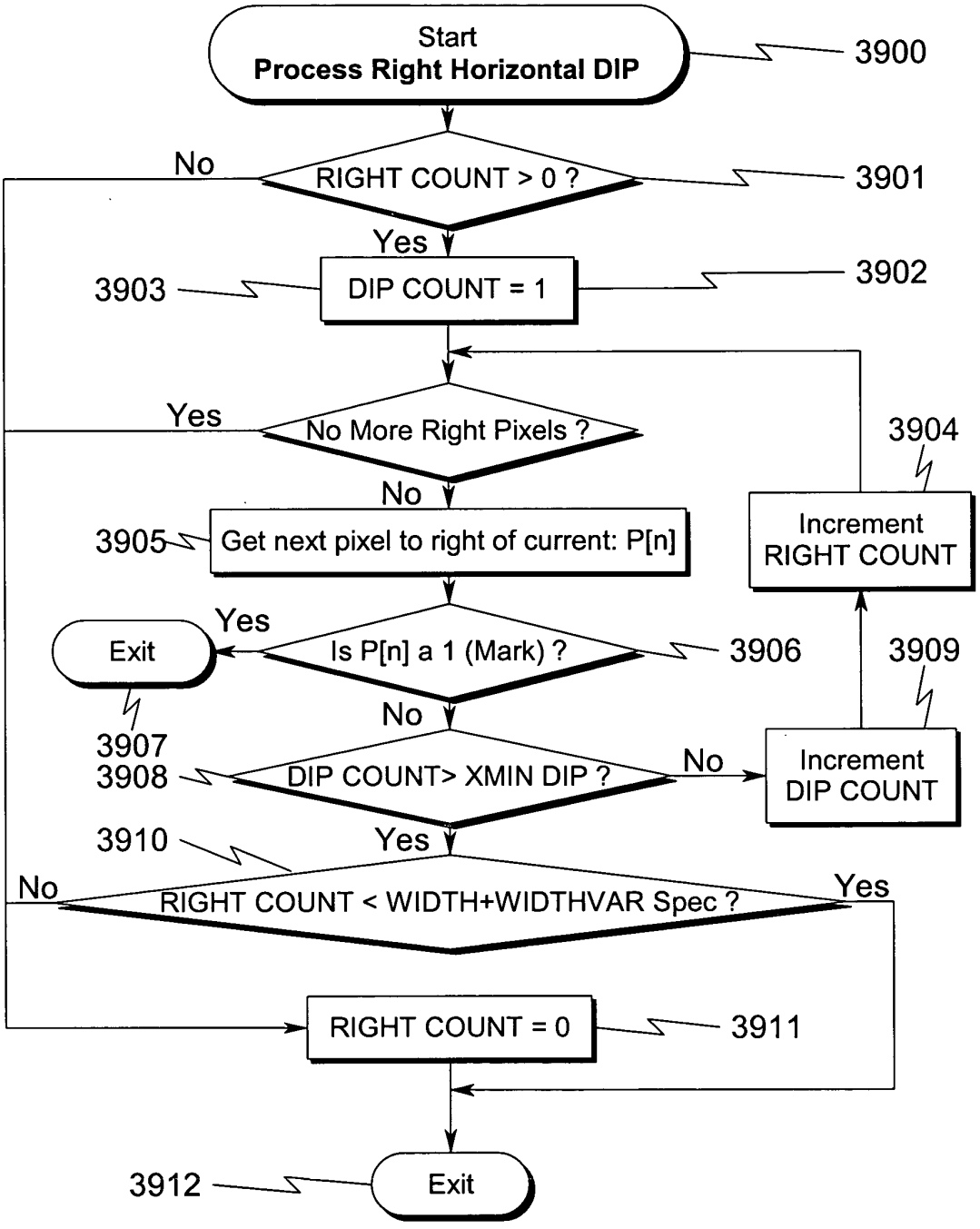

Start
Process Right Horizontal DIP
3900
RIGHT COUNT > 0 ?
No
3901
Yes
DIP COUNT = 1
3903
3902
No More Right Pixels ?
Yes
3904
No
Get next pixel to right of current: P[n]
3905
Increment
RIGHT COUNT
Is P[n] a 1 (Mark) ?
Yes
Exit
3906
3909
No
3907
DIP COUNT> XMIN DIP ?
3908
No
Increment
DIP COUNT
3910
Yes
RIGHT COUNT < WIDTH+WIDTHVAR Spec ?
No
Yes
RIGHT COUNT = 0
3911
3912
Exit

FIG. 40

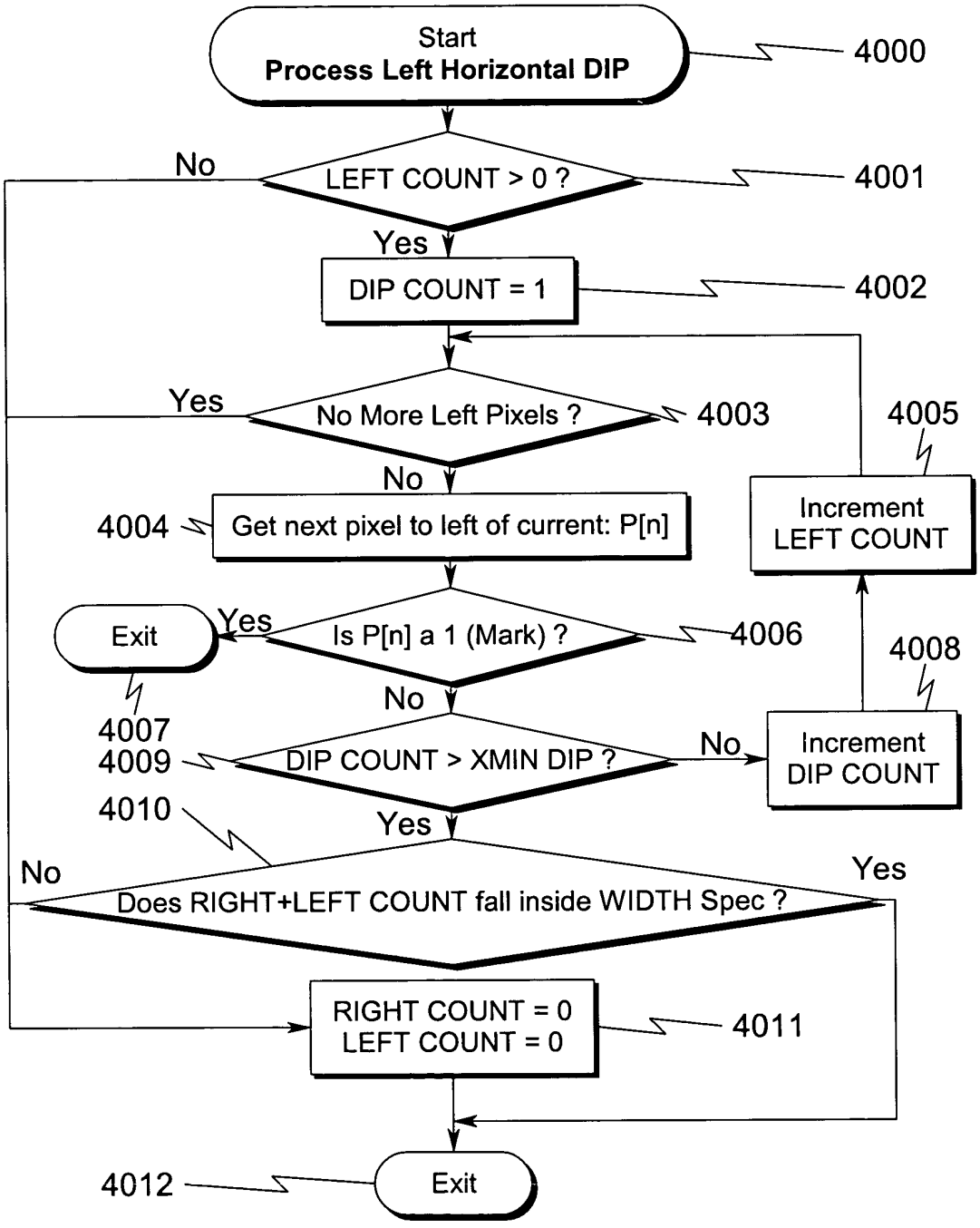

Start
Process Left Horizontal DIP
4000
LEFT COUNT > 0 ?
No
4001
Yes
DIP COUNT = 1
4002
No More Left Pixels ?
Yes
4003
4005
No
Get next pixel to left of current: P[n]
4004
Increment
LEFT COUNT
Exit
Yes
Is P[n] a 1 (Mark) ?
4006
4008
No
4007
4009
DIP COUNT > XMIN DIP ?
No
Increment
DIP COUNT
4010
Yes
No
Yes
Does RIGHT+LEFT COUNT fall inside WIDTH Spec ?
RIGHT COUNT = 0
LEFT COUNT = 0
4011
4012
Exit

FIG. 41

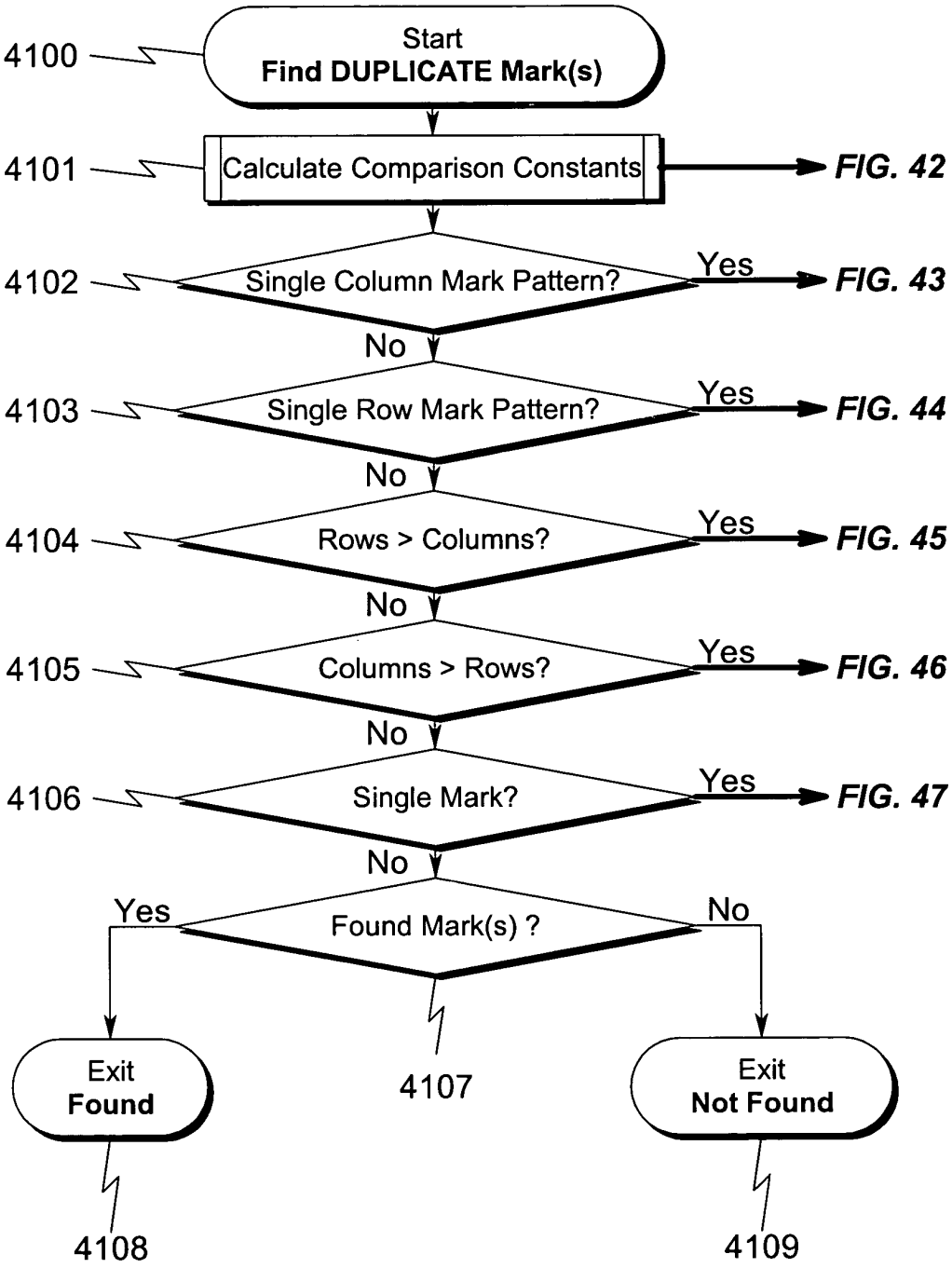

4100
Start
Find DUPLICATE Mark(s)
4101
Calculate Comparison Constants
FIG. 42
4102
Single Column Mark Pattern?
Yes
FIG. 43
No
4103
Single Row Mark Pattern?
Yes
FIG. 44
No
4104
Rows > Columns?
Yes
FIG. 45
No
4105
Columns > Rows?
Yes
FIG. 46
No
4106
Single Mark?
Yes
FIG. 47
No
Yes
Found Mark(s) ?
No
Exit
Found
4107
Exit
Not Found
4108
4109

FIG. 42

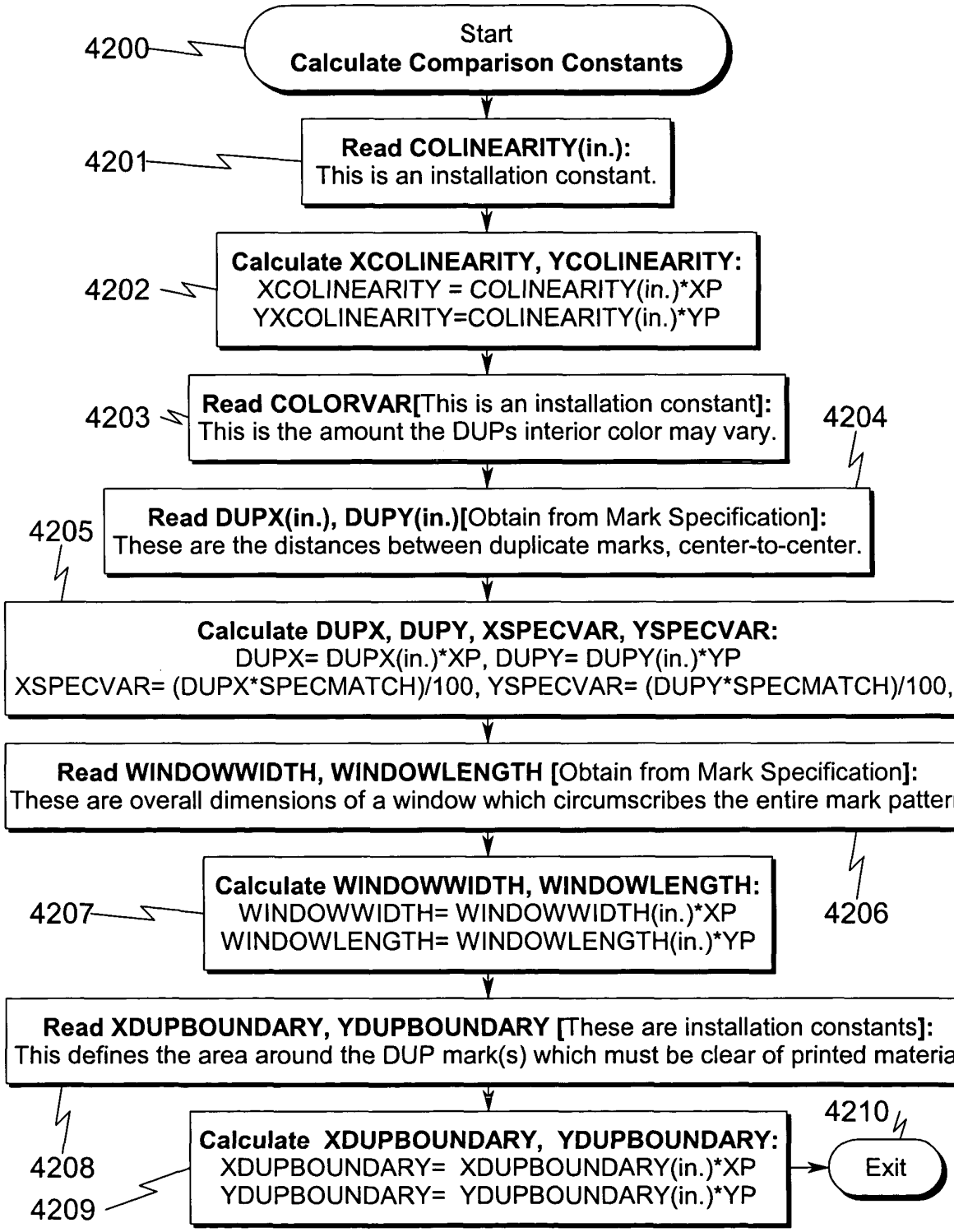

4200
Start
Calculate Comparison Constants
4201
Read COLINEARITY(in.):
This is an installation constant.
4202
Calculate XCOLINEARITY, YCOLINEARITY:
XCOLINEARITY = COLINEARITY(in.)*XP
YXCOLINEARITY=COLINEARITY(in.)*YP
4203
Read COLORVAR[This is an installation constant]:
This is the amount the DUPs interior color may vary.
4204
4205
Read DUPX(in.), DUPY(in.)[Obtain from Mark Specification]:
These are the distances between duplicate marks, center-to-center.
Calculate DUPX, DUPY, XSPECVAR, YSPECVAR:
DUPX= DUPX(in.)*XP, DUPY= DUPY(in.)*YP
XSPECVAR= (DUPX*SPECMATCH)/100, YSPECVAR= (DUPY*SPECMATCH)/100,
Read WINDOWWIDTH, WINDOWLENGTH [Obtain from Mark Specification]:
These are overall dimensions of a window which circumscribes the entire mark pattern
4206
4207
Calculate WINDOWWIDTH, WINDOWLENGTH:
WINDOWWIDTH= WINDOWWIDTH(in.)*XP
WINDOWLENGTH= WINDOWLENGTH(in.)*YP
Read XDUPBOUNDARY, YDUPBOUNDARY [These are installation constants]:
This defines the area around the DUP mark(s) which must be clear of printed material
4208
4209
Calculate XDUPBOUNDARY, YDUPBOUNDARY:
XDUPBOUNDARY= XDUPBOUNDARY(in.)*XP
YDUPBOUNDARY= YDUPBOUNDARY(in.)*YP
4210
Exit

FIG. 43

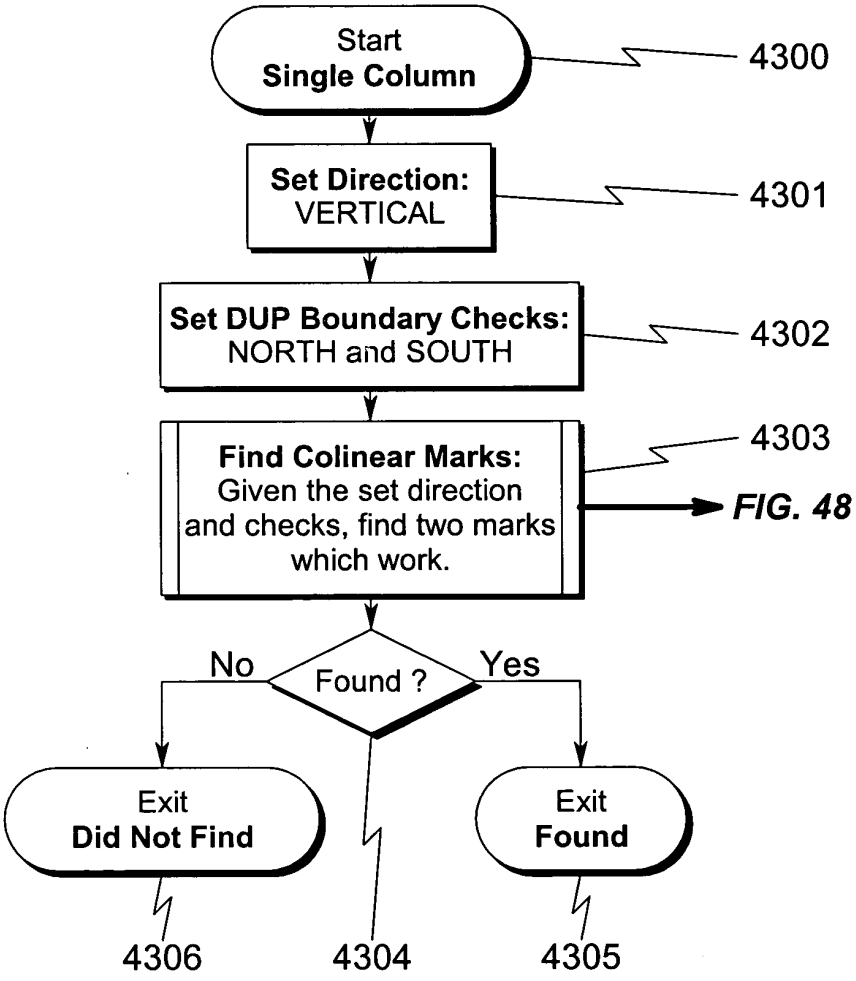

Start
Single Column
4300
Set Direction:
VERTICAL
4301
Set DUP Boundary Checks:
NORTH and SOUTH
4302
Find Colinear Marks:
Given the set direction
and checks, find two marks
which work.
4303
FIG. 48
No
Found ?
Yes
Exit
Did Not Find
Exit
Found
4306
4304
4305

FIG. 44

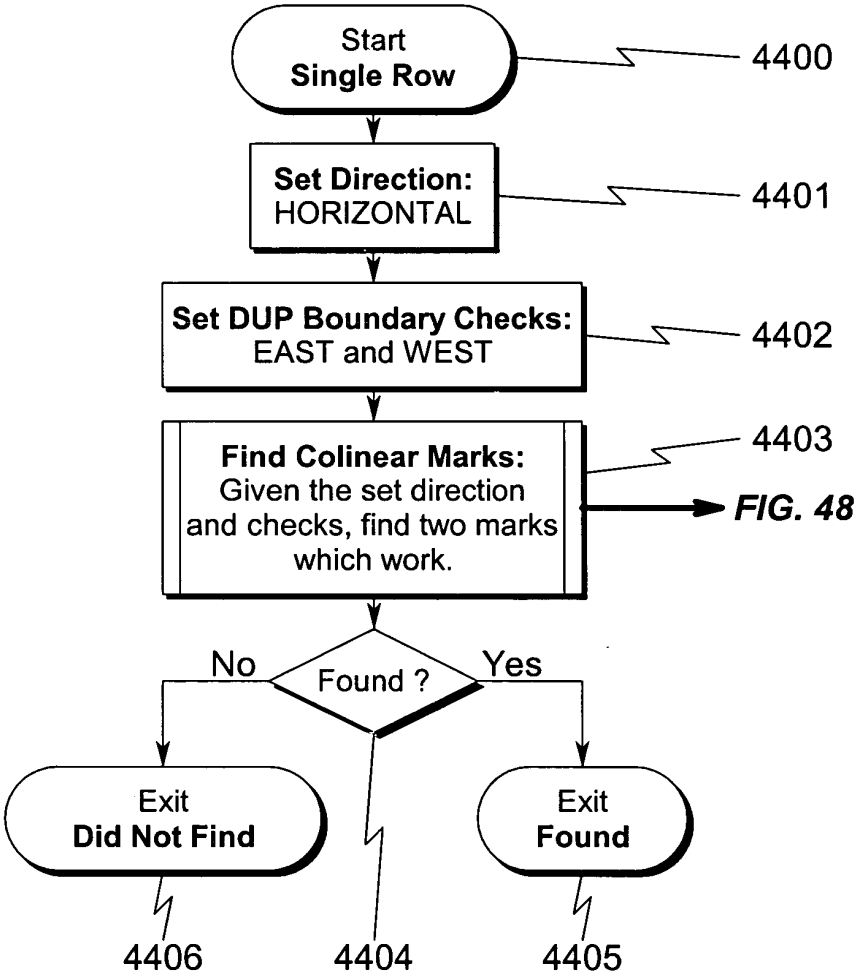

Start
Single Row
4400
Set Direction:
HORIZONTAL
4401
Set DUP Boundary Checks:
EAST and WEST
4402
Find Colinear Marks:
Given the set direction
and checks, find two marks
which work.
4403
FIG. 48
No
Found ?
Yes
Exit
Did Not Find
Exit
Found
4406
4404
4405

FIG. 45

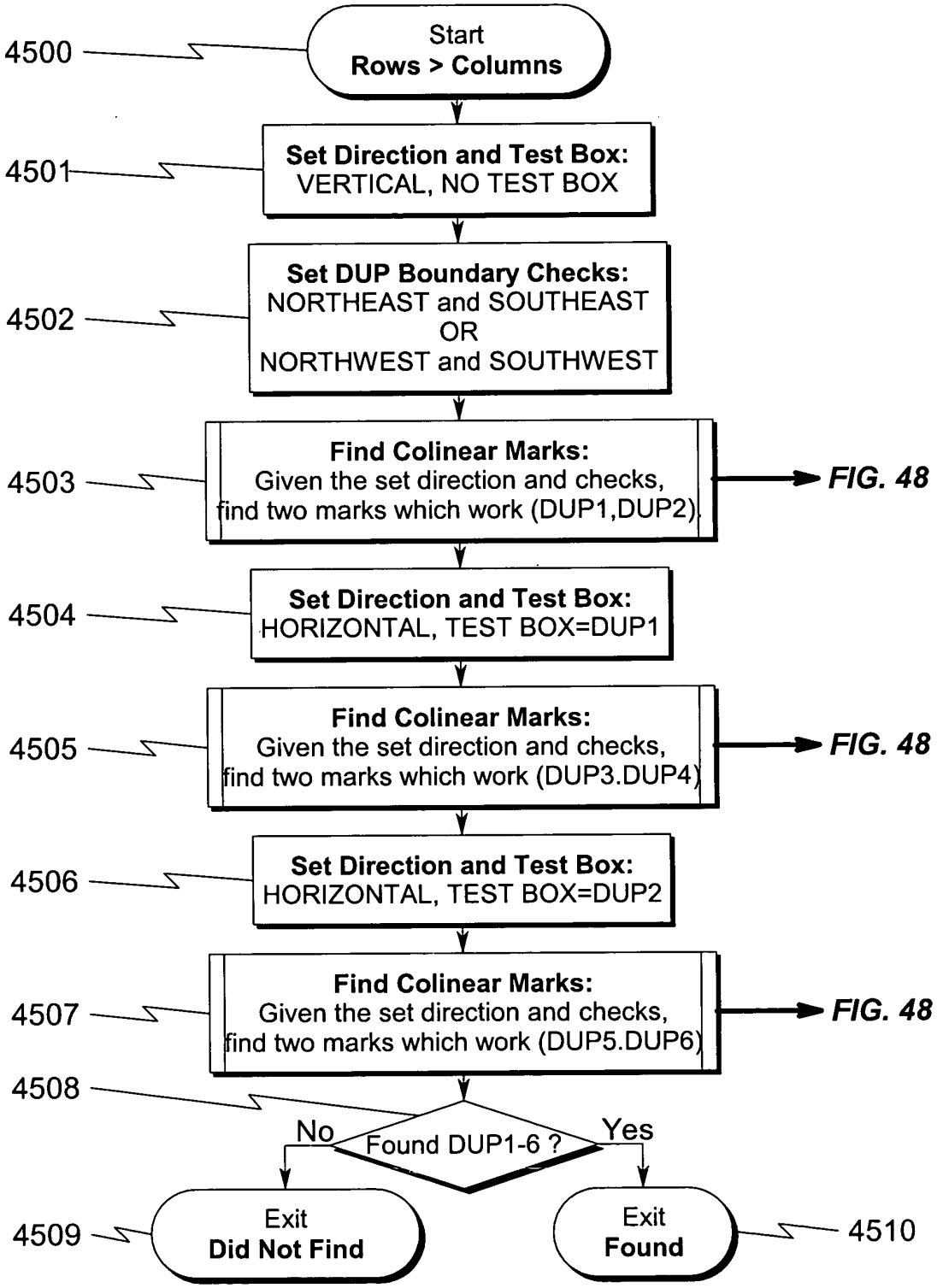

4500
Start
Rows > Columns
4501
Set Direction and Test Box:
VERTICAL, NO TEST BOX
4502
Set DUP Boundary Checks:
NORTHEAST and SOUTHEAST
OR
NORTHWEST and SOUTHWEST
4503
Find Colinear Marks:
Given the set direction and checks,
find two marks which work (DUP1,DUP2)
FIG. 48
4504
Set Direction and Test Box:
HORIZONTAL, TEST BOX=DUP1
4505
Find Colinear Marks:
Given the set direction and checks,
find two marks which work (DUP3.DUP4)
FIG. 48
4506
Set Direction and Test Box:
HORIZONTAL, TEST BOX=DUP2
4507
Find Colinear Marks:
Given the set direction and checks,
find two marks which work (DUP5.DUP6)
FIG. 48
4508
No
Found DUP1-6 ?
Yes
4509
Exit
Did Not Find
Exit
Found
4510

FIG. 46

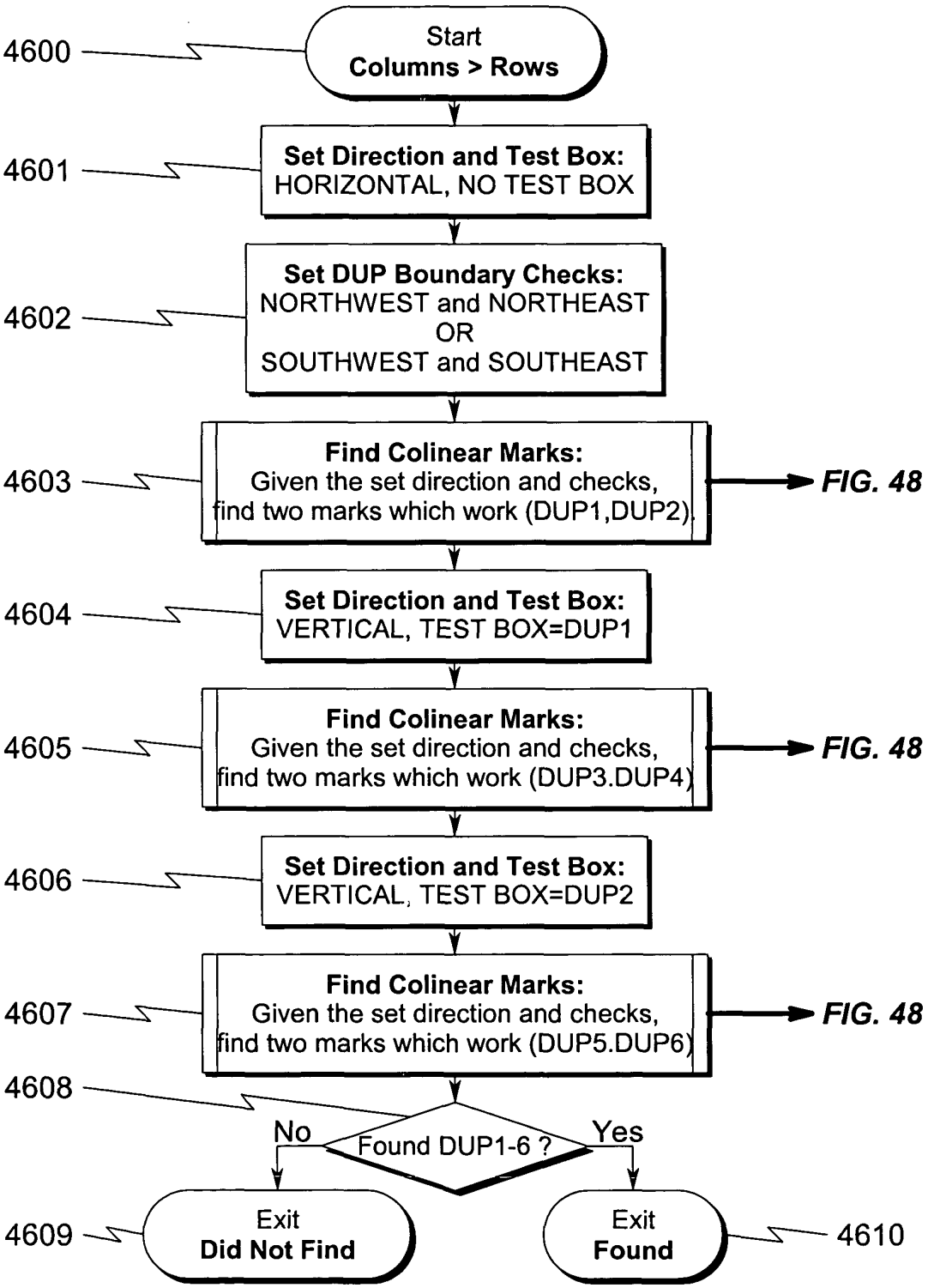

4600
Start
Columns > Rows
4601
Set Direction and Test Box:
HORIZONTAL, NO TEST BOX
4602
Set DUP Boundary Checks:
NORTHWEST and NORTHEAST
OR
SOUTHWEST and SOUTHEAST
4603
Find Colinear Marks:
Given the set direction and checks,
find two marks which work (DUP1,DUP2).
FIG. 48
4604
Set Direction and Test Box:
VERTICAL, TEST BOX=DUP1
4605
Find Colinear Marks:
Given the set direction and checks,
find two marks which work (DUP3.DUP4)
FIG. 48
4606
Set Direction and Test Box:
VERTICAL, TEST BOX=DUP2
4607
Find Colinear Marks:
Given the set direction and checks,
find two marks which work (DUP5.DUP6)
FIG. 48
4608
No
Found DUP1-6 ?
Yes
4609
Exit
Did Not Find
Exit
Found
4610

FIG. 47

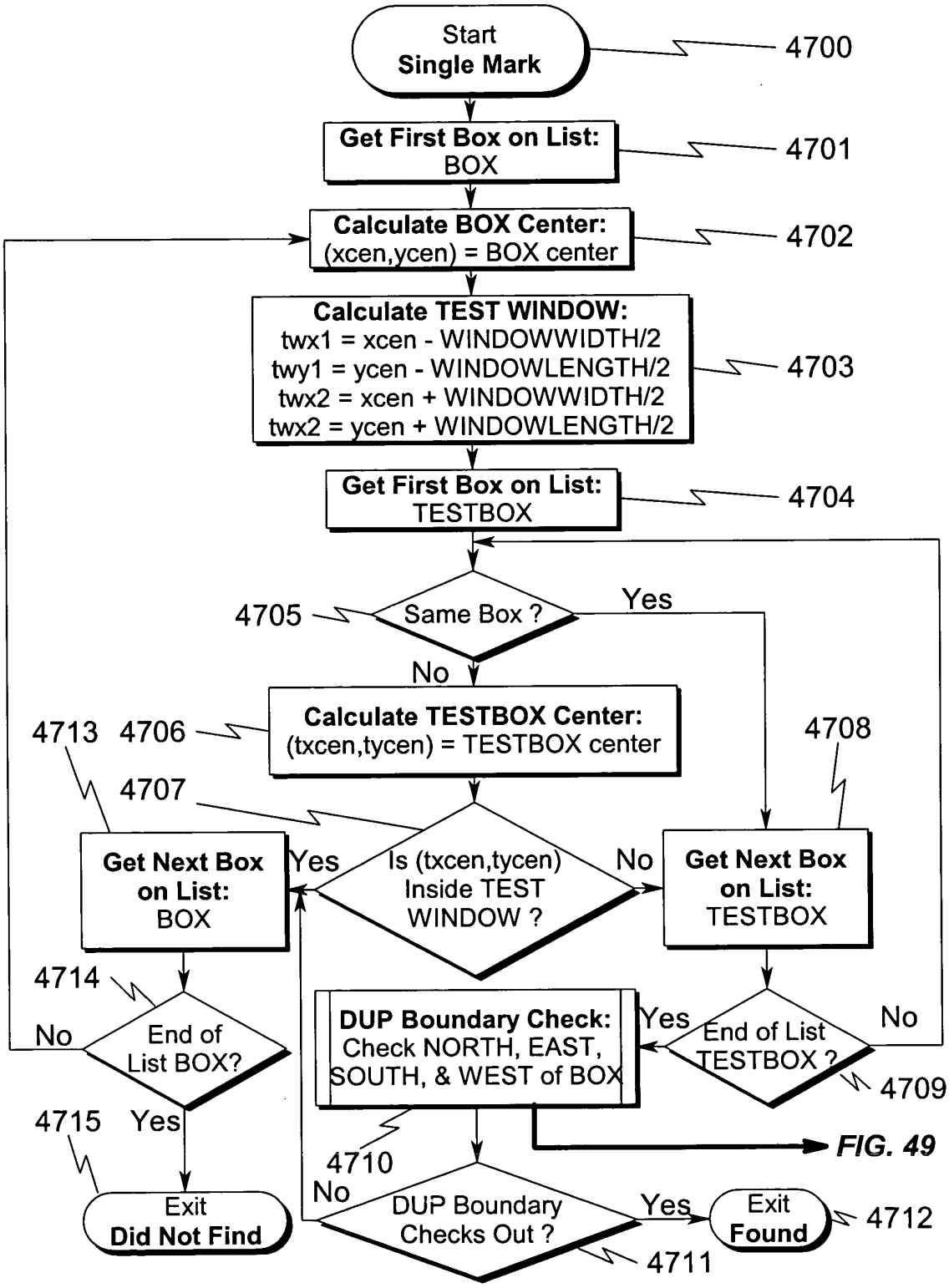

Start
Single Mark
4700
Get First Box on List:
BOX
4701
Calculate BOX Center:
(xcen,ycen) = BOX center
4702
Calculate TEST WINDOW:
twx1 = xcen - WINDOWWIDTH/2
twy1 = ycen - WINDOWLENGTH/2
twx2 = xcen + WINDOWWIDTH/2
twx2 = ycen + WINDOWLENGTH/2
4703
Get First Box on List:
TESTBOX
4704
4705
Same Box ?
Yes
No
4713
4706
Calculate TESTBOX Center:
(txcen,tycen) = TESTBOX center
4708
4707
Get Next Box
on List:
BOX
Yes
Is (txcen,tycen)
Inside TEST
WINDOW ?
No
Get Next Box
on List:
TESTBOX
4714
No
End of
List BOX?
DUP Boundary Check:
Check NORTH, EAST,
SOUTH, & WEST of BOX
Yes
End of List
TESTBOX ?
No
4709
4715
Yes
FIG. 49
4710
No
DUP Boundary
Checks Out ?
Yes
Exit
Found
4712
4711
Exit
Did Not Find

FIG. 48

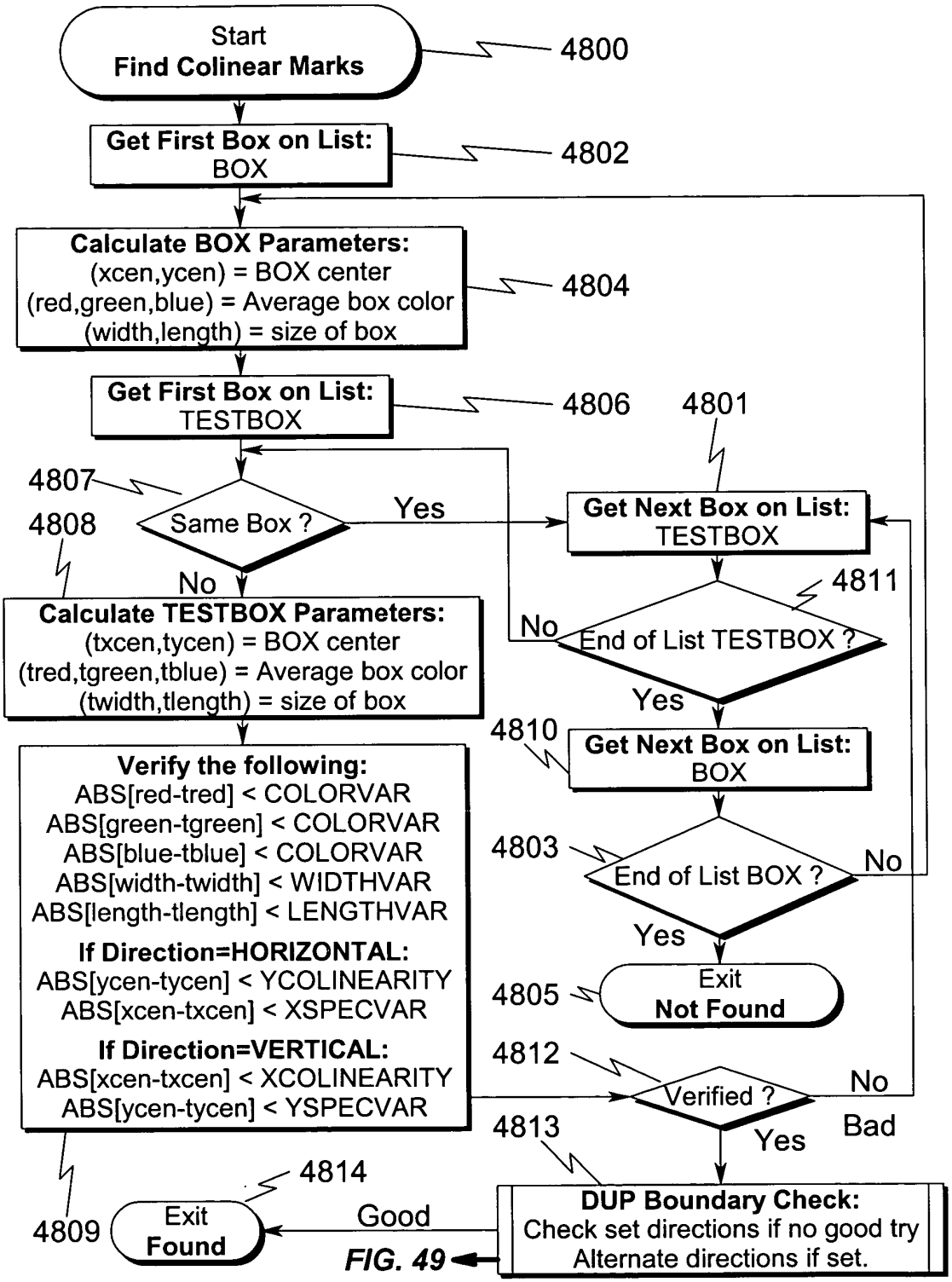

Start
Find Colinear Marks
4800
Get First Box on List:
BOX
4802
Calculate BOX Parameters:
(xcen,ycen) = BOX center
(red,green,blue) = Average box color
(width,length) = size of box
4804
Get First Box on List:
TESTBOX
4806
4801
4807
4808
Same Box ?
Yes
No
Get Next Box on List:
TESTBOX
4811
No
End of List TESTBOX ?
Yes
Calculate TESTBOX Parameters:
(txcen,tycen) = BOX center
(tred,tgreen,tblue) = Average box color
(twidth,tlength) = size of box
4810
Get Next Box on List:
BOX
4803
End of List BOX ?
No
Yes
Verify the following:
ABS[red-tred] < COLORVAR
ABS[green-tgreen] < COLORVAR
ABS[blue-tblue] < COLORVAR
ABS[width-twidth] < WIDTHVAR
ABS[length-tlength] < LENGTHVAR
If Direction=HORIZONTAL:
ABS[ycen-tycen] < YCOLINEARITY
ABS[xcen-txcen] < XSPECVAR
If Direction=VERTICAL:
ABS[xcen-txcen] < XCOLINEARITY
ABS[ycen-tycen] < YSPECVAR
4805
Exit
Not Found
4812
Verified ?
No
Yes
Bad
4813
DUP Boundary Check:
Check set directions if no good try
Alternate directions if set.
4814
Exit
Found
Good
4809
FIG. 49

FIG. 49

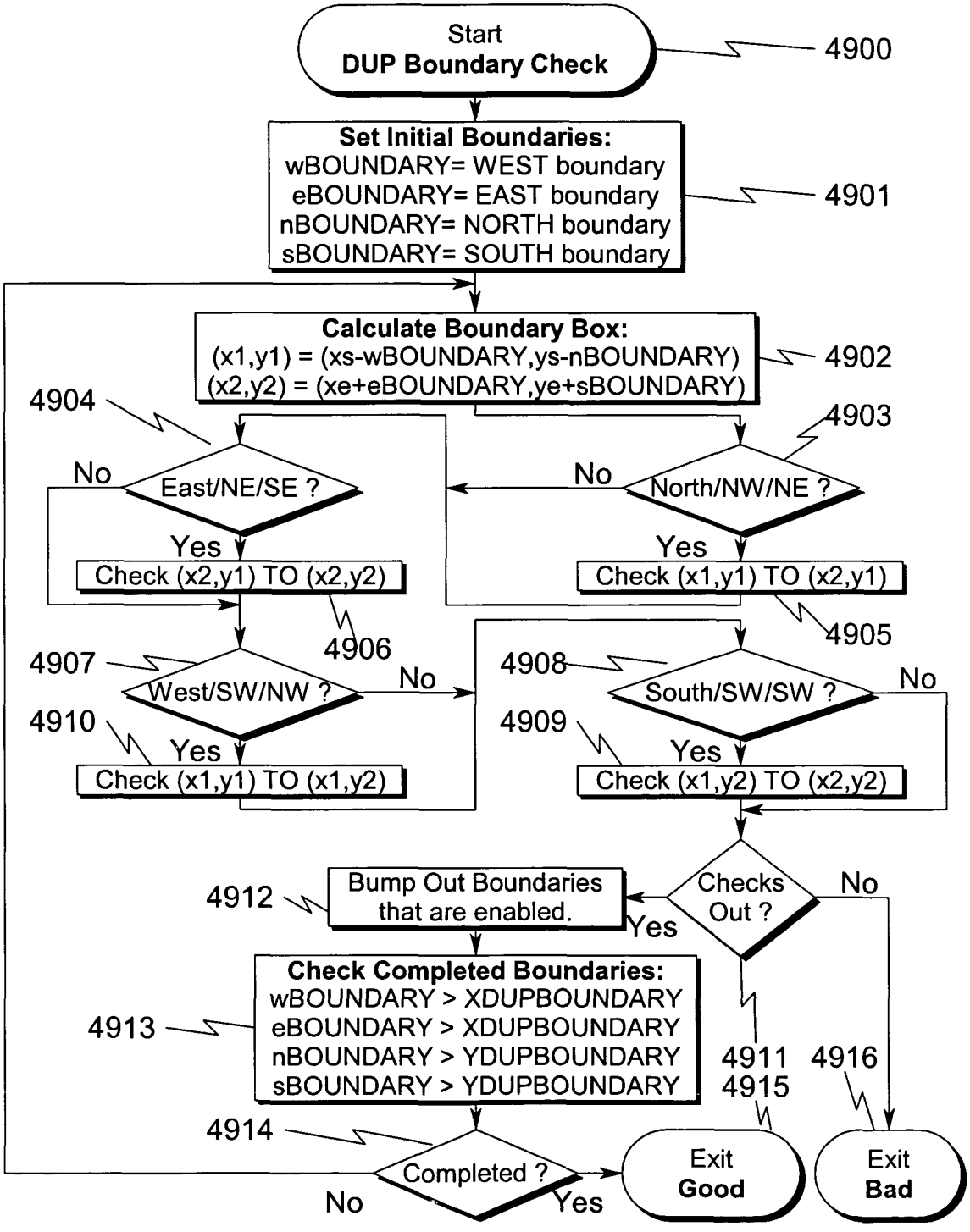

Start
DUP Boundary Check
4900
Set Initial Boundaries:
wBOUNDARY= WEST boundary
eBOUNDARY= EAST boundary
nBOUNDARY= NORTH boundary
sBOUNDARY= SOUTH boundary
4901
Calculate Boundary Box:
(x1,y1) = (xs-wBOUNDARY,ys-nBOUNDARY)
(x2,y2) = (xe+eBOUNDARY,ye+sBOUNDARY)
4902
4904
4903
No
East/NE/SE ?
No
North/NW/NE ?
Yes
Check (x2,y1) TO (x2,y2)
Yes
Check (x1,y1) TO (x2,y1)
4906
4905
4907
West/SW/NW ?
No
4908
South/SW/SW ?
No
4910
Yes
Check (x1,y1) TO (x1,y2)
4909
Yes
Check (x1,y2) TO (x2,y2)
Checks Out ?
No
4912
Bump Out Boundaries that are enabled.
Yes
Check Completed Boundaries:
wBOUNDARY > XDUPBOUNDARY
eBOUNDARY > XDUPBOUNDARY
nBOUNDARY > YDUPBOUNDARY
sBOUNDARY > YDUPBOUNDARY
4913
4911
4915
4916
4914
Completed ?
No
Yes
Exit
Good
Exit
Bad

FIG. 50

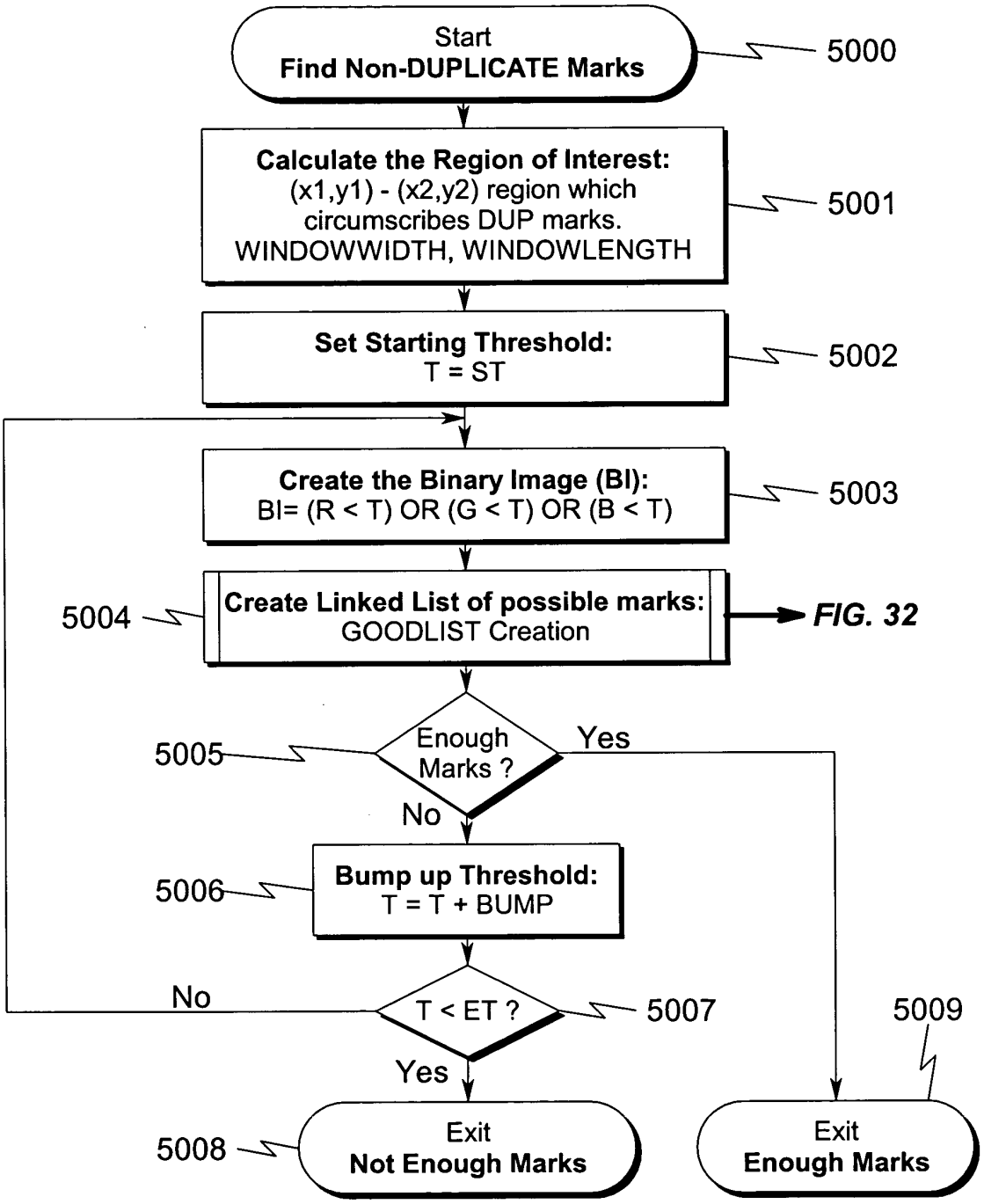

Start
Find Non-DUPLICATE Marks
5000
Calculate the Region of Interest:
(x1,y1) - (x2,y2) region which
circumscribes DUP marks.
WINDOWWIDTH, WINDOWLENGTH
5001
Set Starting Threshold:
T = ST
5002
Create the Binary Image (BI):
BI= (R < T) OR (G < T) OR (B < T)
5003
5004
Create Linked List of possible marks:
GOODLIST Creation
FIG. 32
5005
Enough
Marks ?
Yes
No
5006
Bump up Threshold:
T = T + BUMP
No
T < ET ?
5007
5009
Yes
5008
Exit
Not Enough Marks
Exit
Enough Marks

FIG. 51

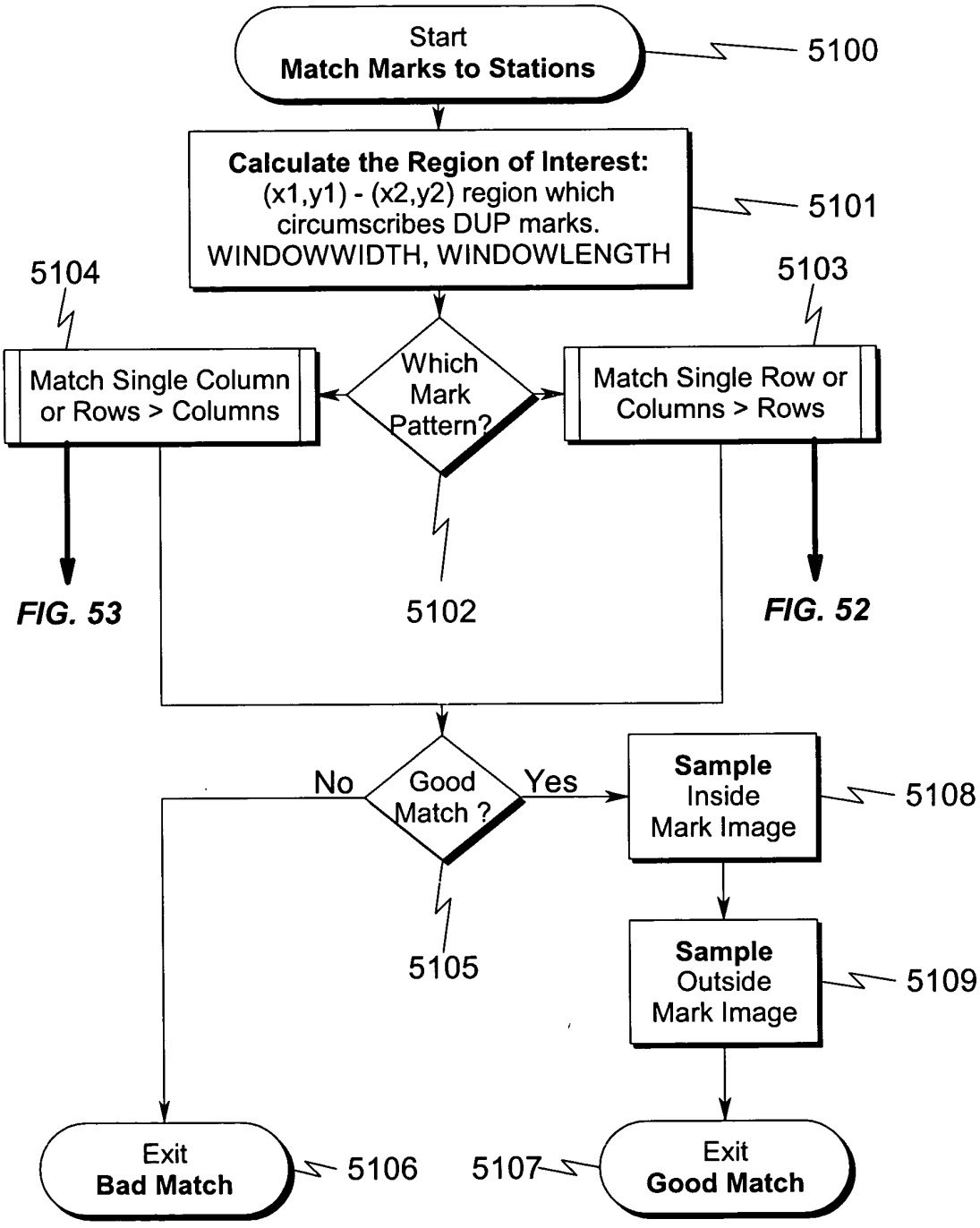

Start
Match Marks to Stations
5100
Calculate the Region of Interest:
(x1,y1) - (x2,y2) region which
circumscribes DUP marks.
WINDOWWIDTH, WINDOWLENGTH
5101
5104
5103
Match Single Column
or Rows > Columns
Which
Mark
Pattern?
Match Single Row or
Columns > Rows
FIG. 53
5102
FIG. 52
No
Good
Match ?
Yes
Sample
Inside
Mark Image
5108
5105
Sample
Outside
Mark Image
5109
Exit
Bad Match
5106
5107
Exit
Good Match

FIG. 52

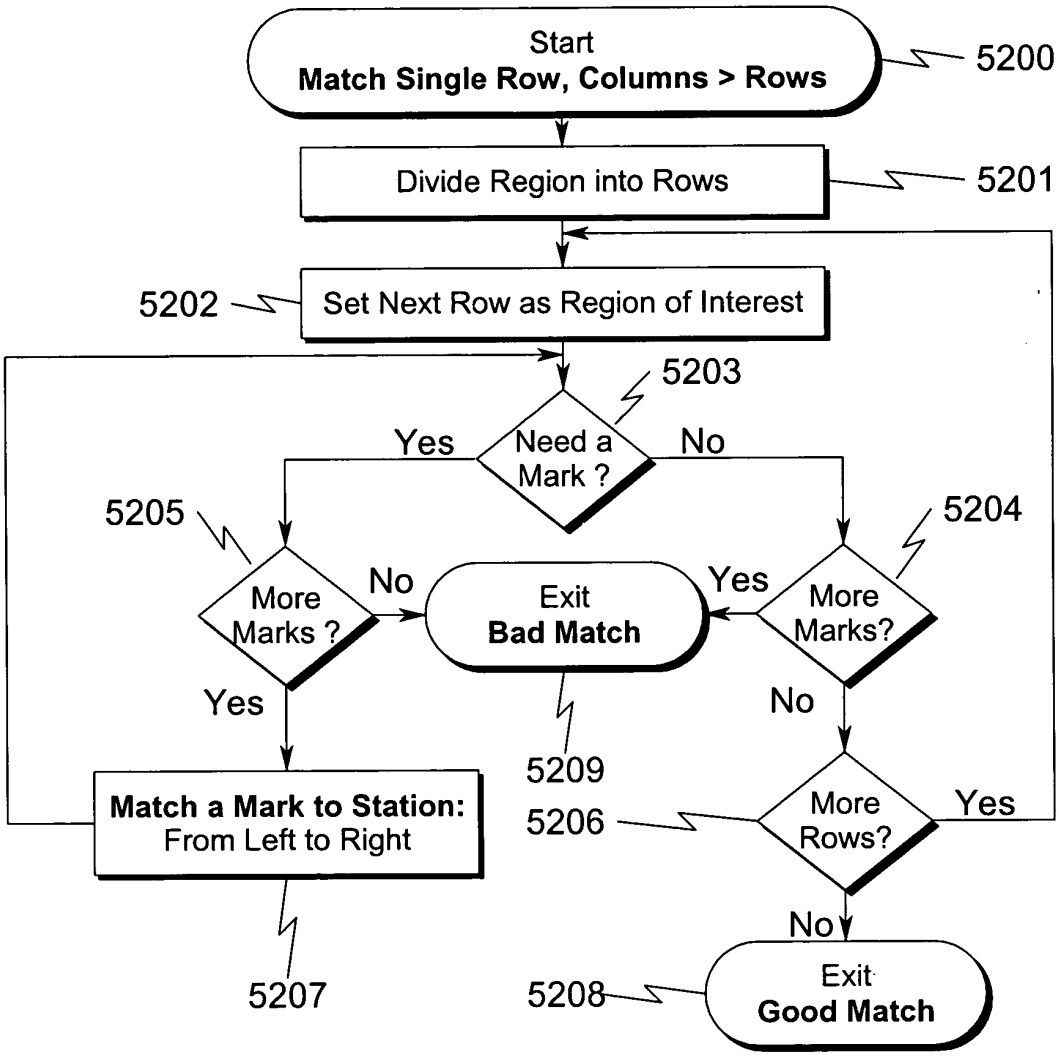

Start
Match Single Row, Columns > Rows
5200
Divide Region into Rows
5201
5202
Set Next Row as Region of Interest
5203
Need a Mark ?
Yes
No
5205
More Marks ?
No
Exit
Bad Match
Yes
5204
More Marks?
Yes
No
5209
Match a Mark to Station:
From Left to Right
5206
More Rows?
Yes
No
5207
5208
Exit
Good Match

FIG. 53

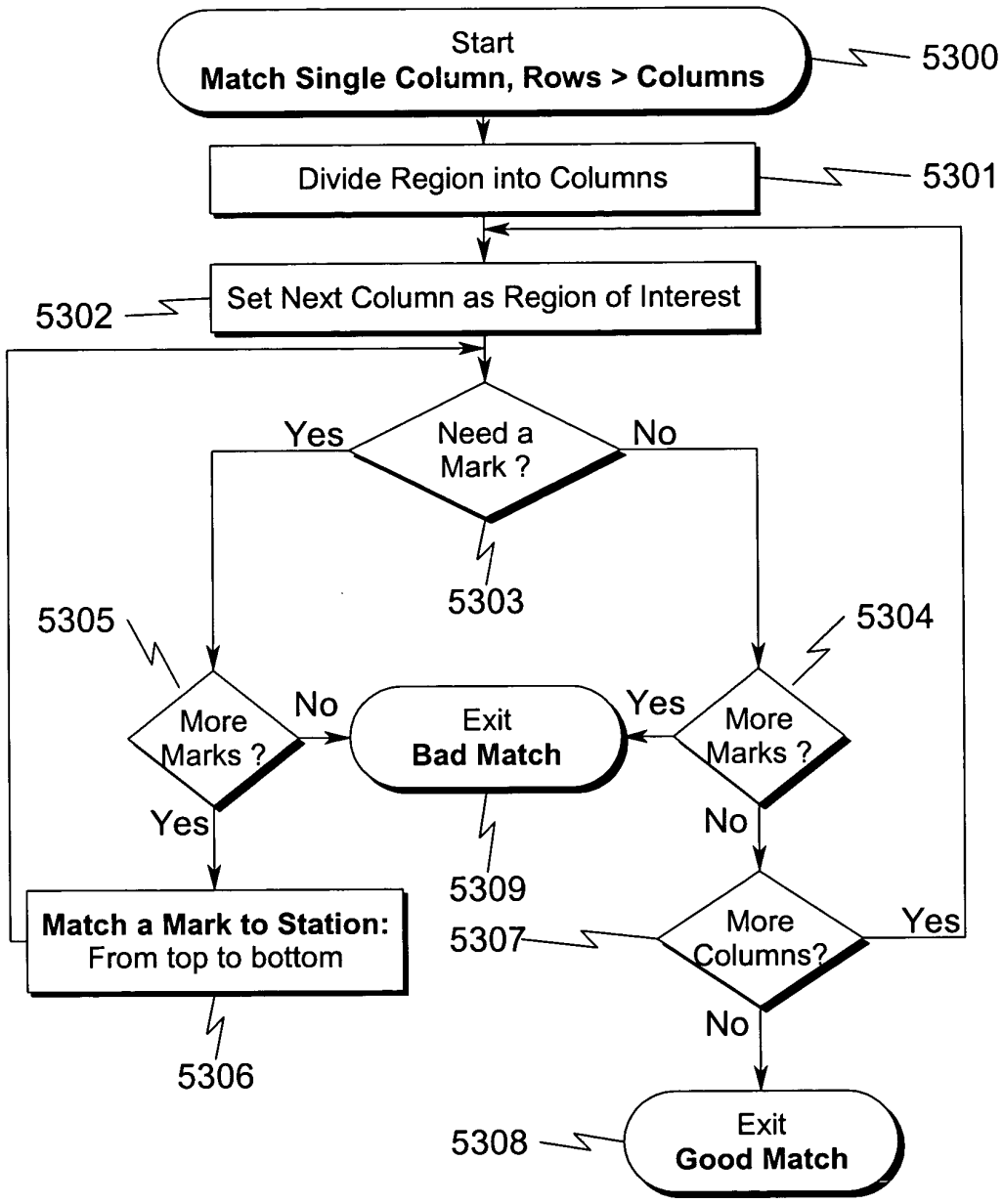

Start
Match Single Column, Rows > Columns
5300
Divide Region into Columns
5301
Set Next Column as Region of Interest
5302
Need a Mark ?
Yes
No
5303
5305
More Marks ?
No
Yes
5304
More Marks ?
Exit
Bad Match
5309
Yes
No
Match a Mark to Station:
From top to bottom
5306
5307
More Columns?
Yes
No
5308
Exit
Good Match

FIG. 54

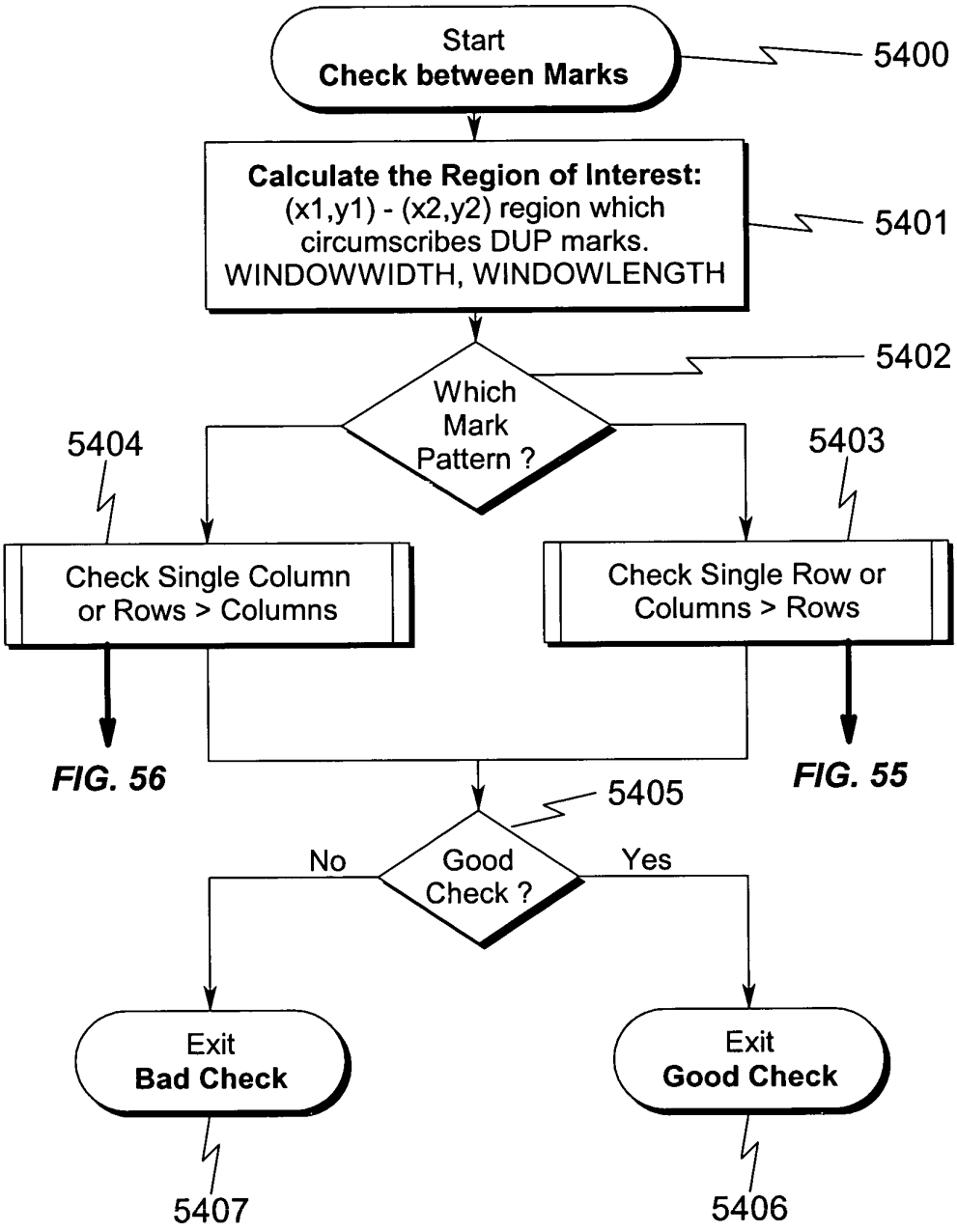

Start
Check between Marks
5400
Calculate the Region of Interest:
(x1,y1) - (x2,y2) region which
circumscribes DUP marks.
WINDOWWIDTH, WINDOWLENGTH
5401
5402
Which
Mark
Pattern ?
5404
5403
Check Single Column
or Rows > Columns
Check Single Row or
Columns > Rows
FIG. 56
FIG. 55
5405
No
Good
Check ?
Yes
Exit
Bad Check
Exit
Good Check
5407
5406

FIG. 55

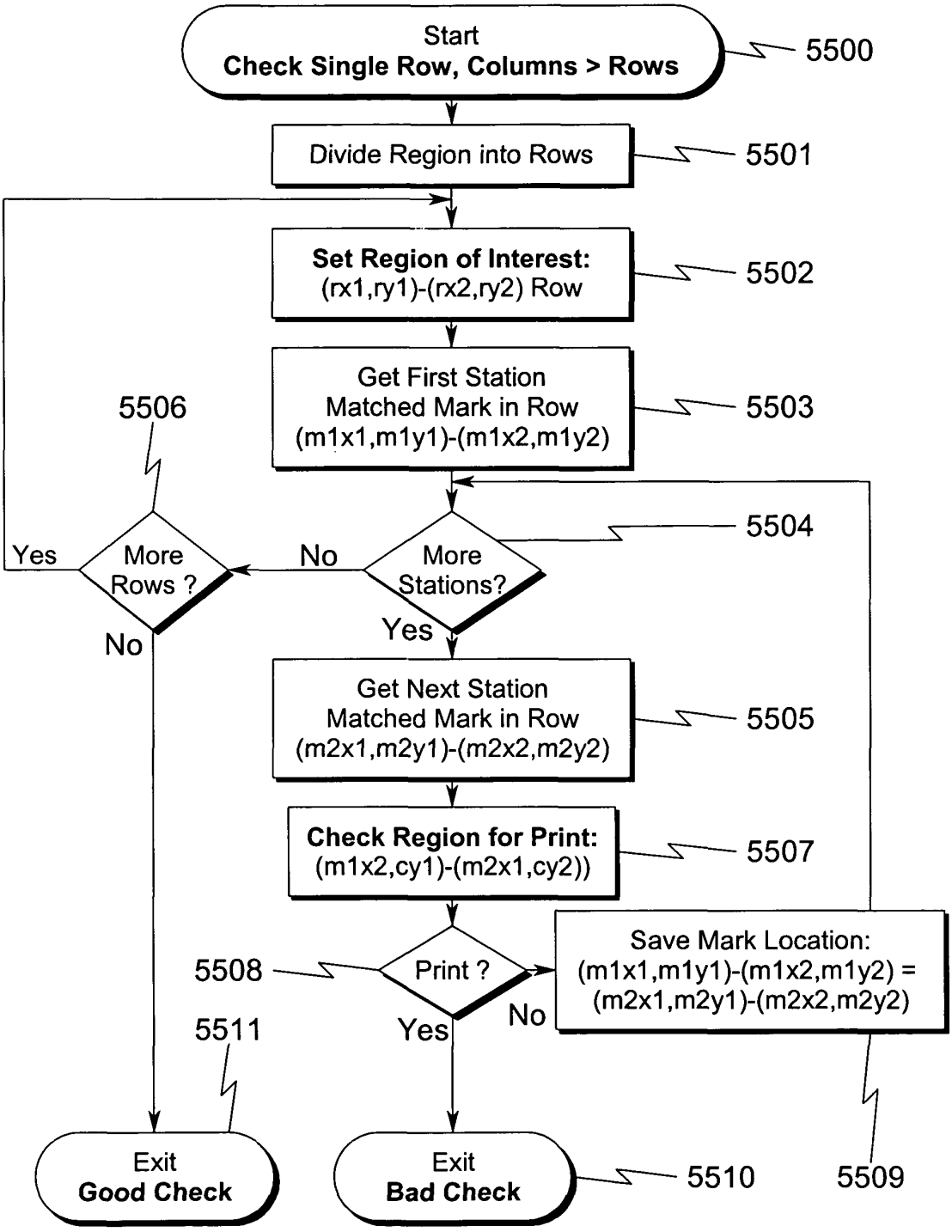

Start
Check Single Row, Columns > Rows
5500
Divide Region into Rows
5501
Set Region of Interest:
(rx1,ry1)-(rx2,ry2) Row
5502
Get First Station
Matched Mark in Row
(m1x1,m1y1)-(m1x2,m1y2)
5503
5506
5504
Yes
More
Rows ?
No
More
Stations?
No
Yes
Get Next Station
Matched Mark in Row
(m2x1,m2y1)-(m2x2,m2y2)
5505
Check Region for Print:
(m1x2,cy1)-(m2x1,cy2))
5507
5508
Print ?
Save Mark Location:
(m1x1,m1y1)-(m1x2,m1y2) =
(m2x1,m2y1)-(m2x2,m2y2)
No
Yes
5511
Exit
Good Check
Exit
Bad Check
5510
5509

FIG. 56

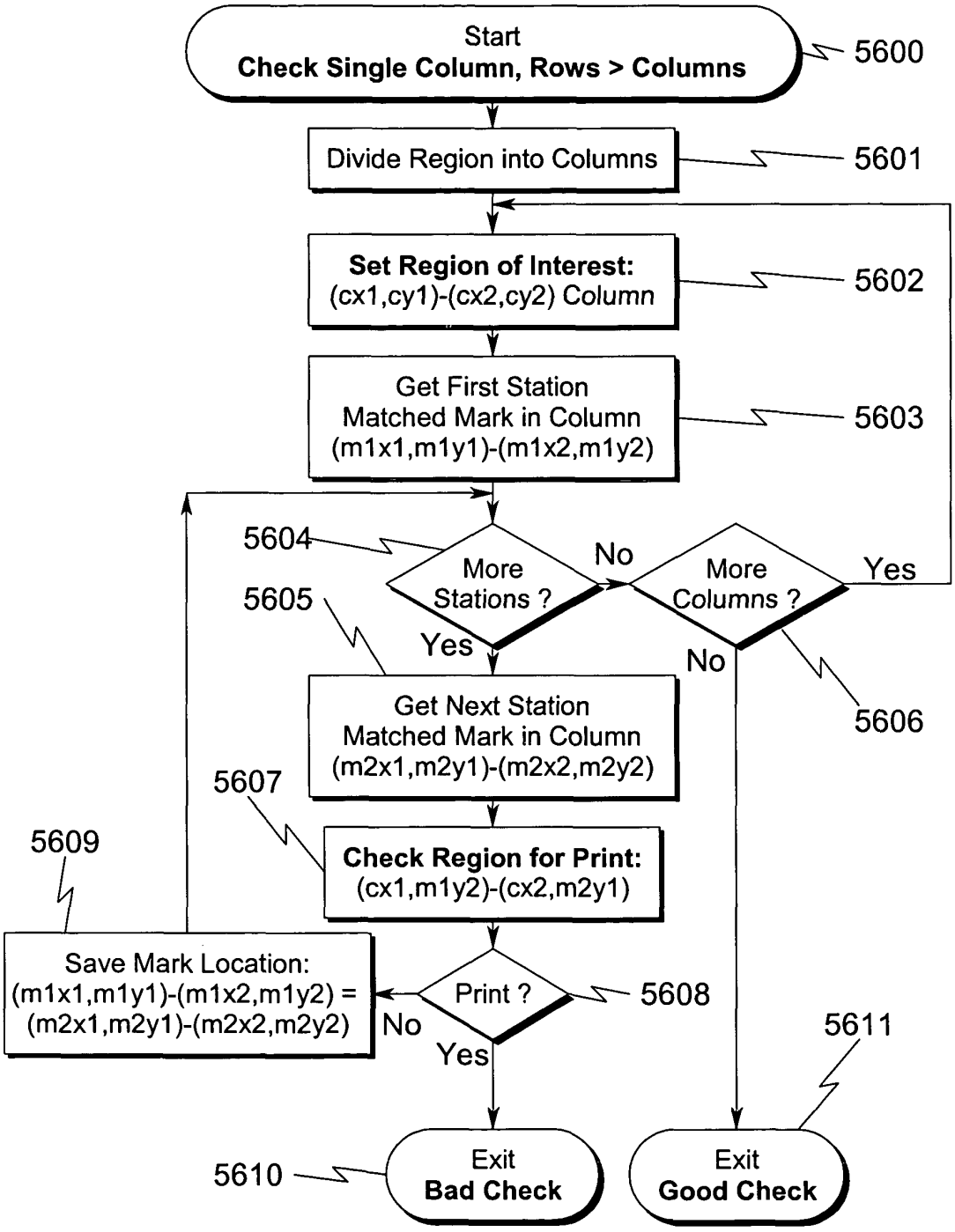

Start
Check Single Column, Rows > Columns
5600
Divide Region into Columns
5601
Set Region of Interest:
(cx1,cy1)-(cx2,cy2) Column
5602
Get First Station
Matched Mark in Column
(m1x1,m1y1)-(m1x2,m1y2)
5603
5604
More
Stations ?
No
More
Columns ?
Yes
5605
Yes
No
5606
Get Next Station
Matched Mark in Column
(m2x1,m2y1)-(m2x2,m2y2)
5607
5609
Check Region for Print:
(cx1,m1y2)-(cx2,m2y1)
Save Mark Location:
(m1x1,m1y1)-(m1x2,m1y2) =
(m2x1,m2y1)-(m2x2,m2y2)
Print ?
5608
No
Yes
5611
5610
Exit
Bad Check
Exit
Good Check

FIG. 57

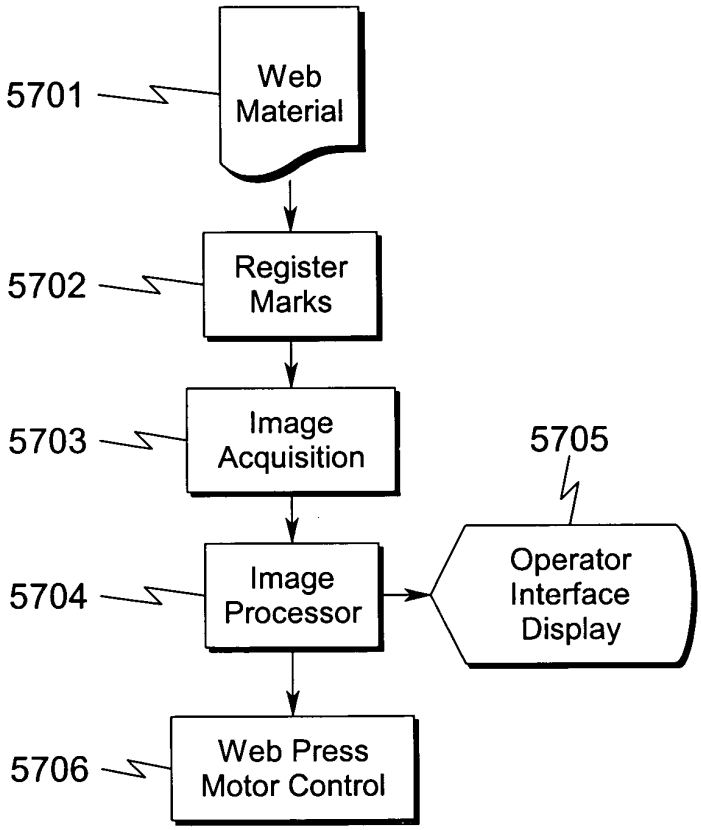

5701
Web Material
5702
Register Marks
5703
Image Acquisition
5705
Operator Interface Display
5704
Image Processor
5706
Web Press Motor Control

FIG. 58

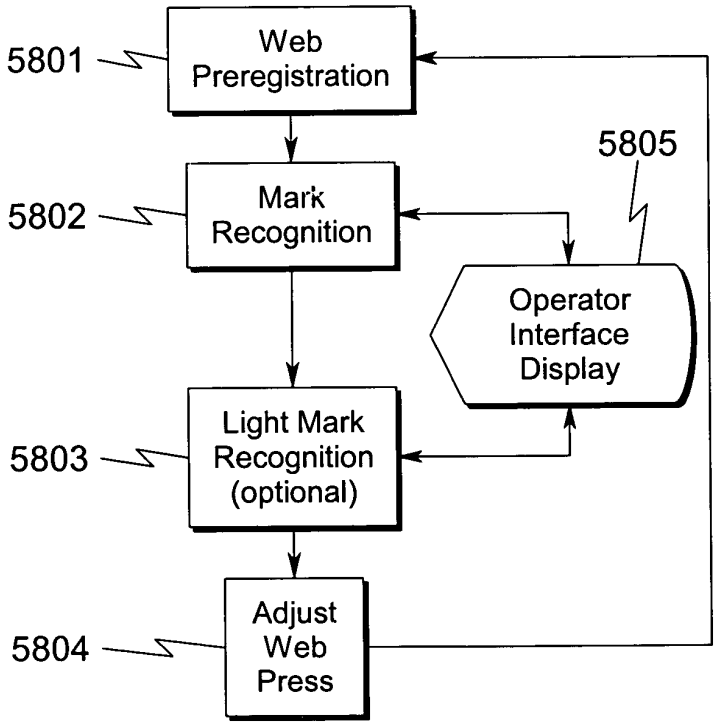

5801
Web Preregistration
5805
5802
Mark Recognition
Operator Interface Display
Light Mark Recognition (optional)
5803
Adjust Web Press
5804

FIG. 59

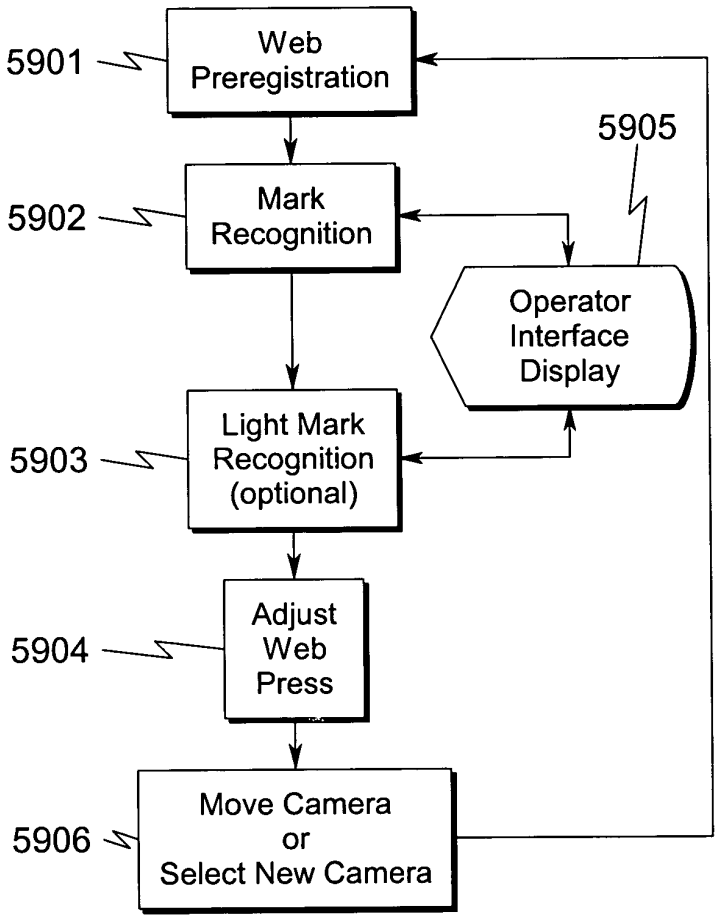

5901
Web Preregistration
5905
5902
Mark Recognition
Operator Interface Display
5903
Light Mark Recognition (optional)
5904
Adjust Web Press
5906
Move Camera or Select New Camera

FIG. 60

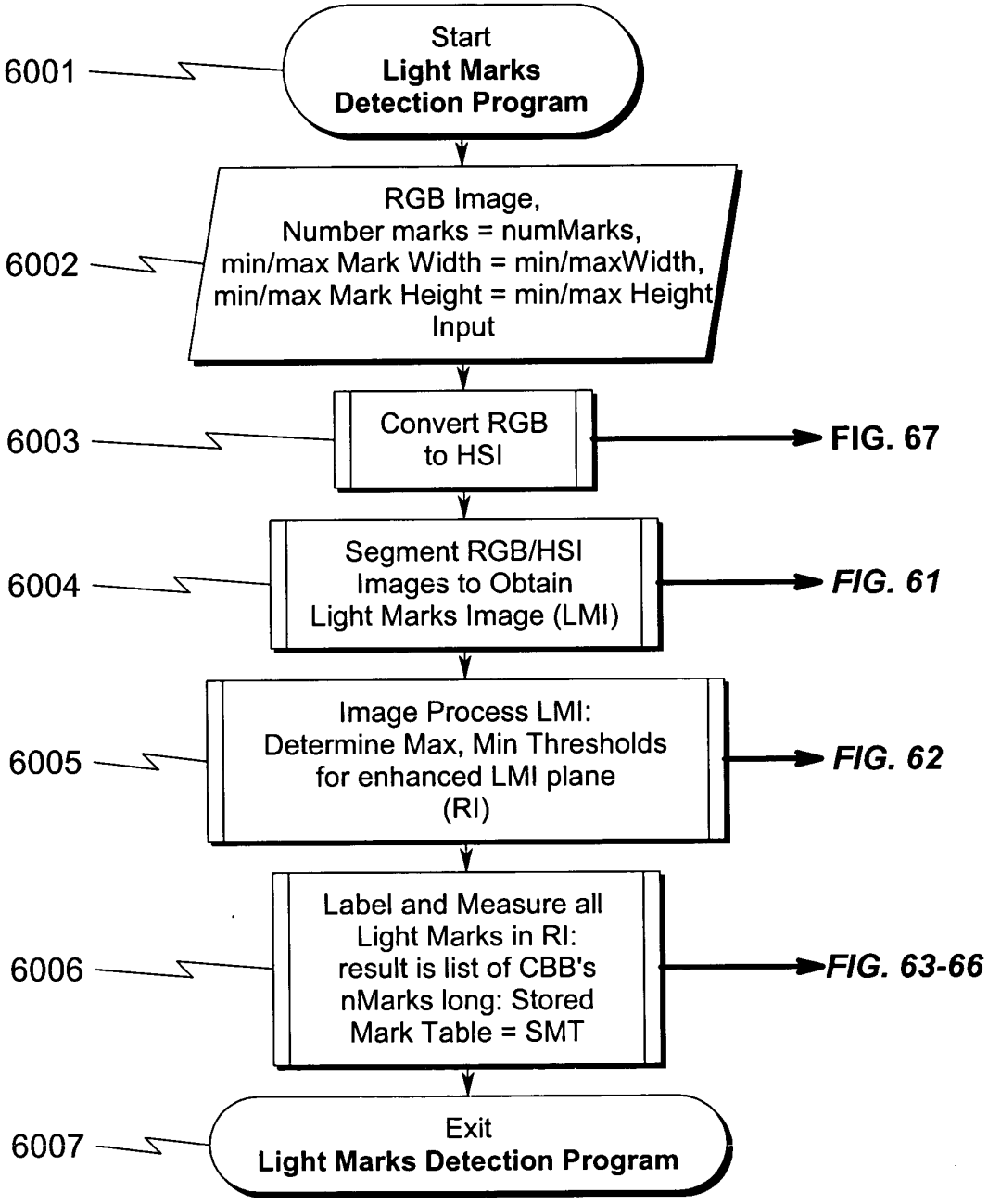

6001
Start
Light Marks
Detection Program
6002
RGB Image,
Number marks = numMarks,
min/max Mark Width = min/maxWidth,
min/max Mark Height = min/max Height
Input
6003
Convert RGB
to HSI
FIG. 67
6004
Segment RGB/HSI
Images to Obtain
Light Marks Image (LMI)
FIG. 61
6005
Image Process LMI:
Determine Max, Min Thresholds
for enhanced LMI plane
(RI)
FIG. 62
6006
Label and Measure all
Light Marks in RI:
result is list of CBB's
nMarks long: Stored
Mark Table = SMT
FIG. 63-66
6007
Exit
Light Marks Detection Program

FIG. 61

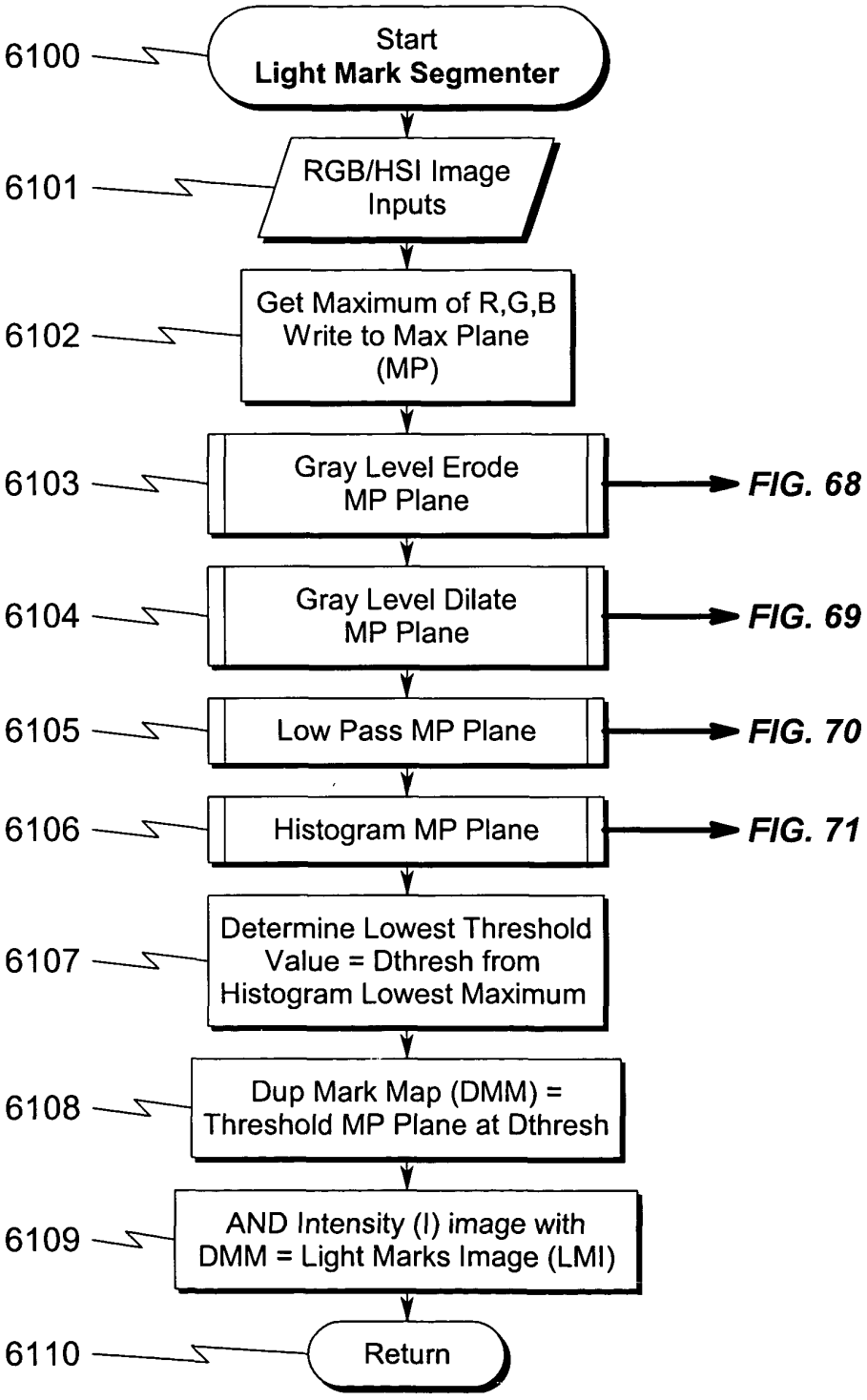

6100
Start
Light Mark Segmenter
6101
RGB/HSI Image Inputs
6102
Get Maximum of R,G,B Write to Max Plane (MP)
6103
Gray Level Erode MP Plane
FIG. 68
6104
Gray Level Dilate MP Plane
FIG. 69
6105
Low Pass MP Plane
FIG. 70
6106
Histogram MP Plane
FIG. 71
6107
Determine Lowest Threshold Value = Dthresh from Histogram Lowest Maximum
6108
Dup Mark Map (DMM) = Threshold MP Plane at Dthresh
6109
AND Intensity (I) image with DMM = Light Marks Image (LMI)
6110
Return

FIG. 62

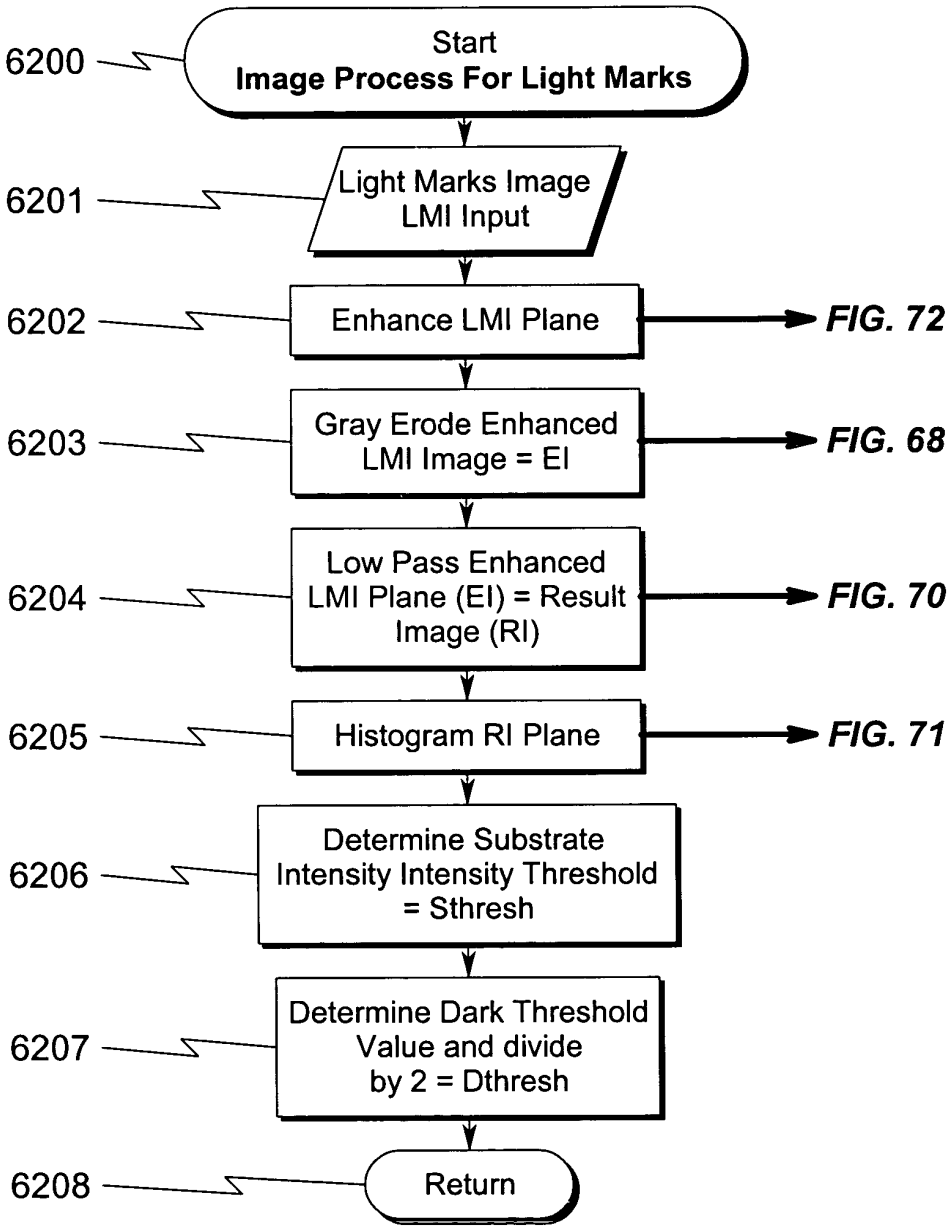

6200
Start
Image Process For Light Marks
6201
Light Marks Image
LMI Input
6202
Enhance LMI Plane
FIG. 72
6203
Gray Erode Enhanced
LMI Image = EI
FIG. 68
6204
Low Pass Enhanced
LMI Plane (EI) = Result
Image (RI)
FIG. 70
6205
Histogram RI Plane
FIG. 71
6206
Determine Substrate
Intensity Intensity Threshold
= Sthresh
6207
Determine Dark Threshold
Value and divide
by 2 = Dthresh
6208
Return

FIG. 63

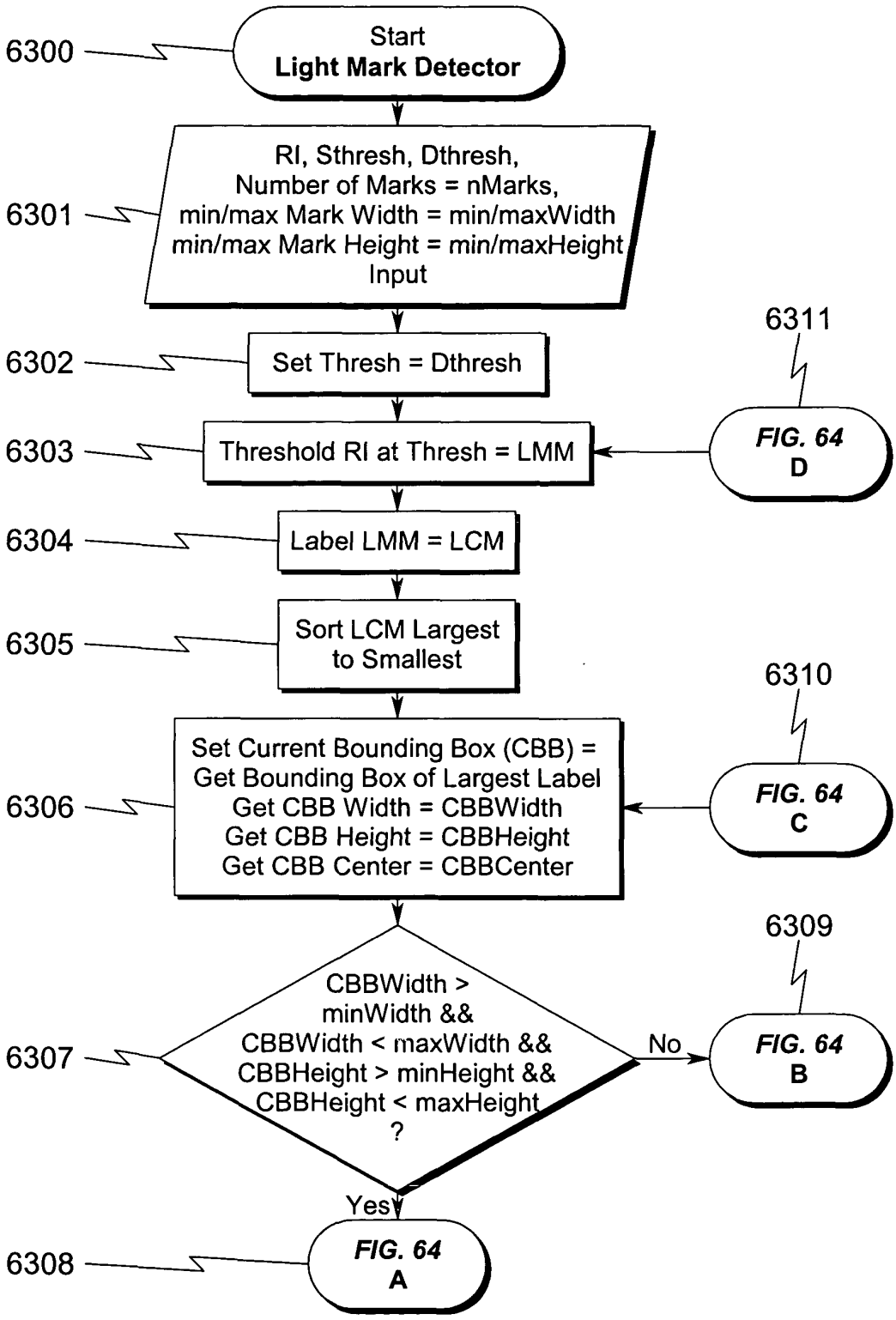

6300
Start
Light Mark Detector
6301
RI, Sthresh, Dthresh,
Number of Marks = nMarks,
min/max Mark Width = min/maxWidth
min/max Mark Height = min/maxHeight
Input
6302
Set Thresh = Dthresh
6303
Threshold RI at Thresh = LMM
6311
FIG. 64
D
6304
Label LMM = LCM
6305
Sort LCM Largest
to Smallest
6306
Set Current Bounding Box (CBB) =
Get Bounding Box of Largest Label
Get CBB Width = CBBWidth
Get CBB Height = CBBHeight
Get CBB Center = CBBCenter
6310
FIG. 64
C
6307
CBBWidth >
minWidth &&
CBBWidth < maxWidth &&
CBBHeight > minHeight &&
CBBHeight < maxHeight
?
No
6309
FIG. 64
B
Yes
6308
FIG. 64
A

FIG. 64

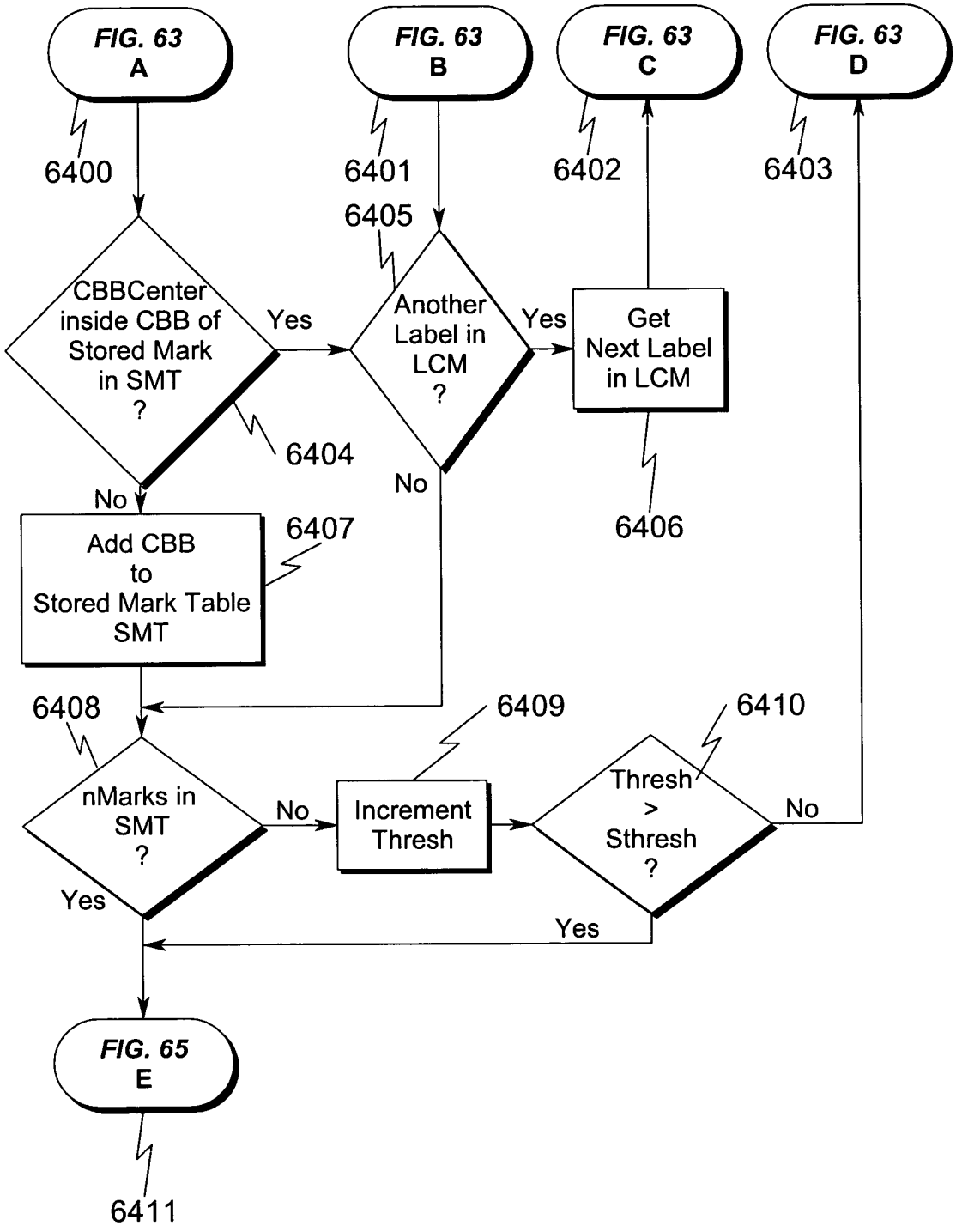


FIG. 63 A
FIG. 63 B
FIG. 63 C
FIG. 63 D
6400
6401
6402
6403
6405
CBBCenter inside CBB of Stored Mark in SMT ?
Yes
Another Label in LCM ?
Yes
Get Next Label in LCM
6404
No
No
6406
Add CBB to Stored Mark Table SMT
6407
6408
6409
6410
nMarks in SMT ?
No
Increment Thresh
Thresh > Sthresh ?
No
Yes
Yes
FIG. 65 E
6411

FIG. 65

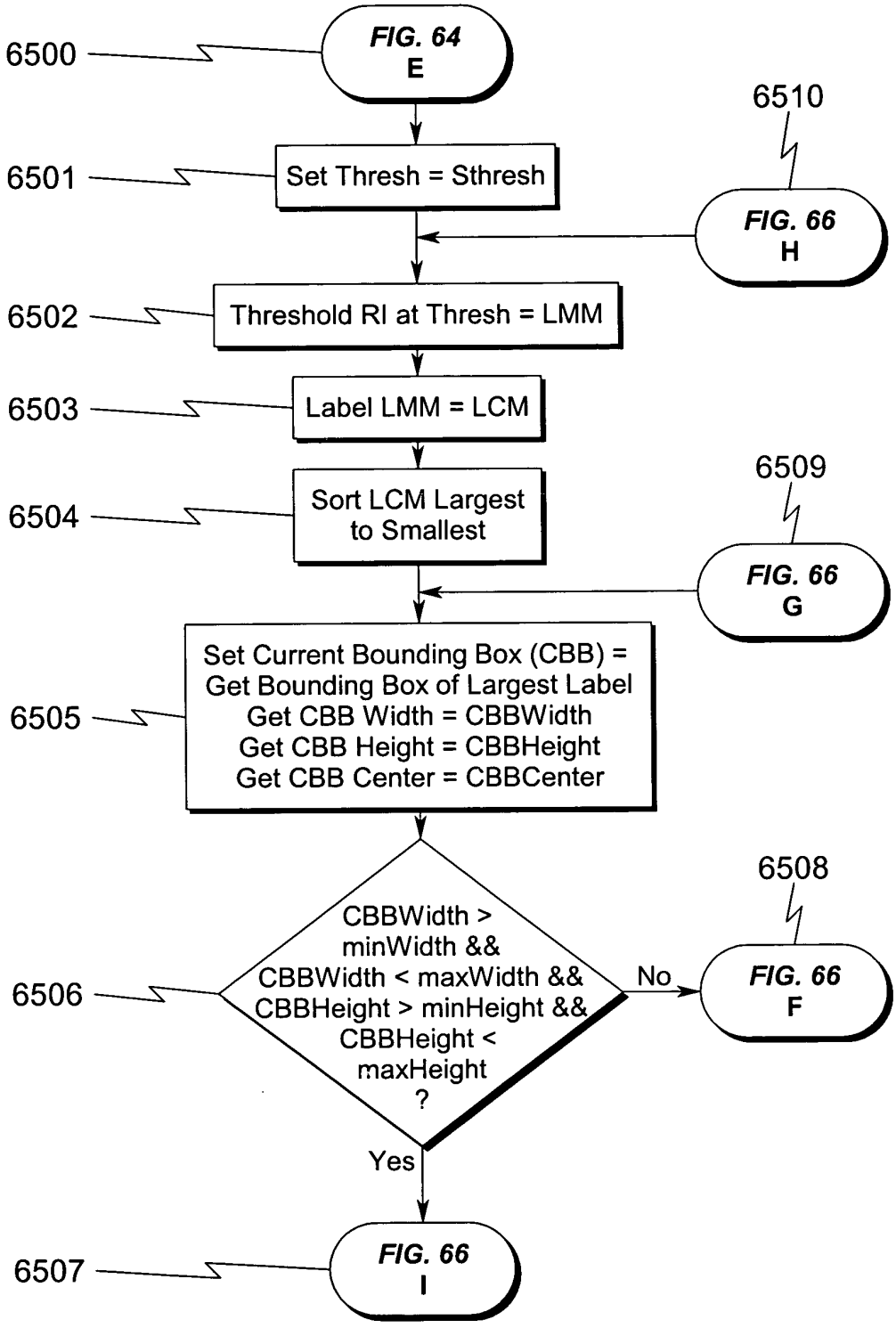

6500
FIG. 64
E
6501
Set Thresh = Sthresh
6510
FIG. 66
H
6502
Threshold RI at Thresh = LMM
6503
Label LMM = LCM
6504
Sort LCM Largest to Smallest
6509
FIG. 66
G
6505
Set Current Bounding Box (CBB) =
Get Bounding Box of Largest Label
Get CBB Width = CBBWidth
Get CBB Height = CBBHeight
Get CBB Center = CBBCenter
6506
CBBWidth > minWidth && CBBWidth < maxWidth && CBBHeight > minHeight && CBBHeight < maxHeight ?
No
6508
FIG. 66
F
Yes
6507
FIG. 66
I

FIG. 66

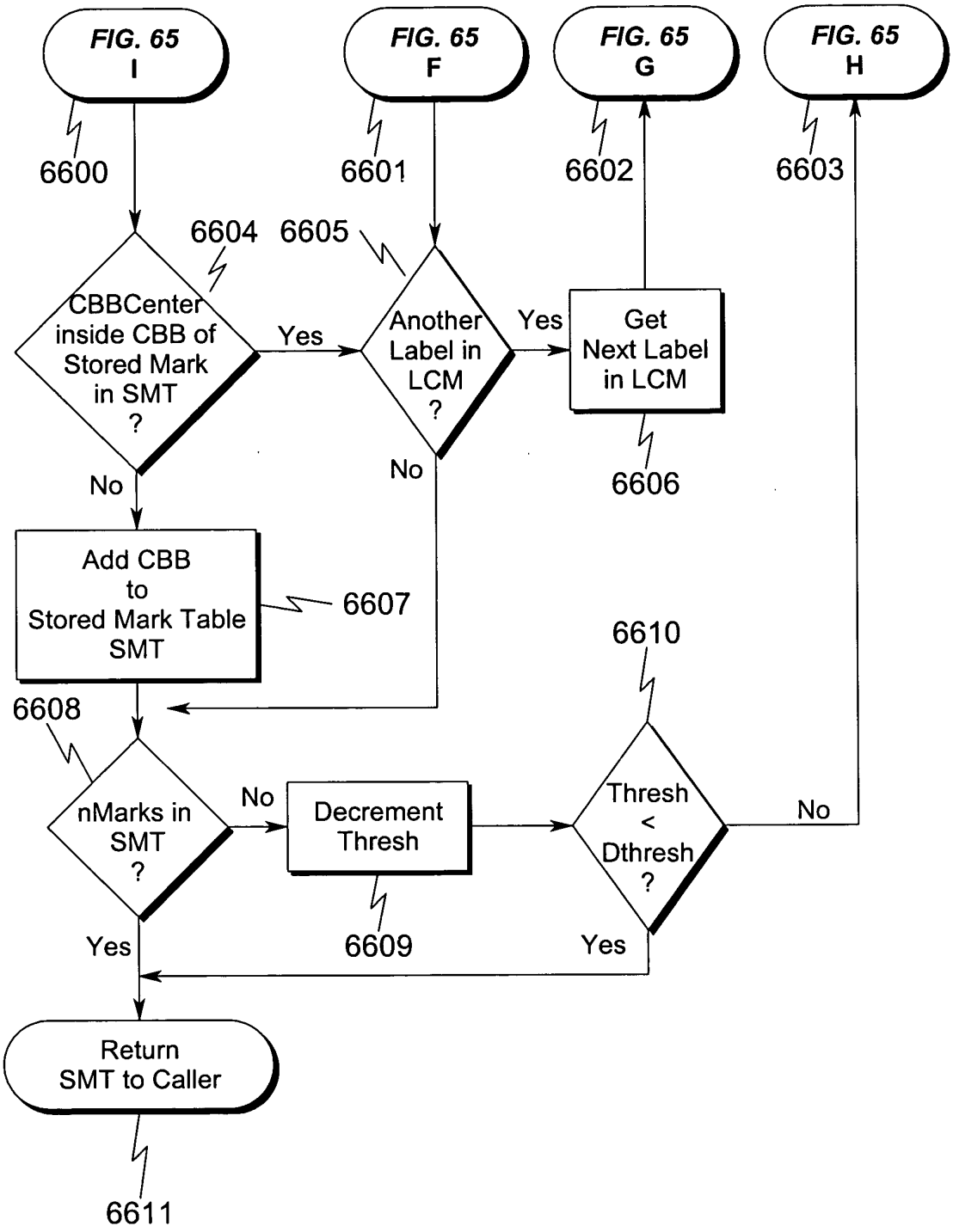


FIG. 65 I
FIG. 65 F
FIG. 65 G
FIG. 65 H
6600
6601
6602
6603
6604
6605
CBBCenter inside CBB of Stored Mark in SMT ?
Yes
Another Label in LCM ?
Yes
Get Next Label in LCM
6606
No
No
Add CBB to Stored Mark Table SMT
6607
6610
6608
nMarks in SMT ?
No
Decrement Thresh
6609
Thresh < Dthresh ?
No
Yes
Yes
Return SMT to Caller
6611

FIG. 67

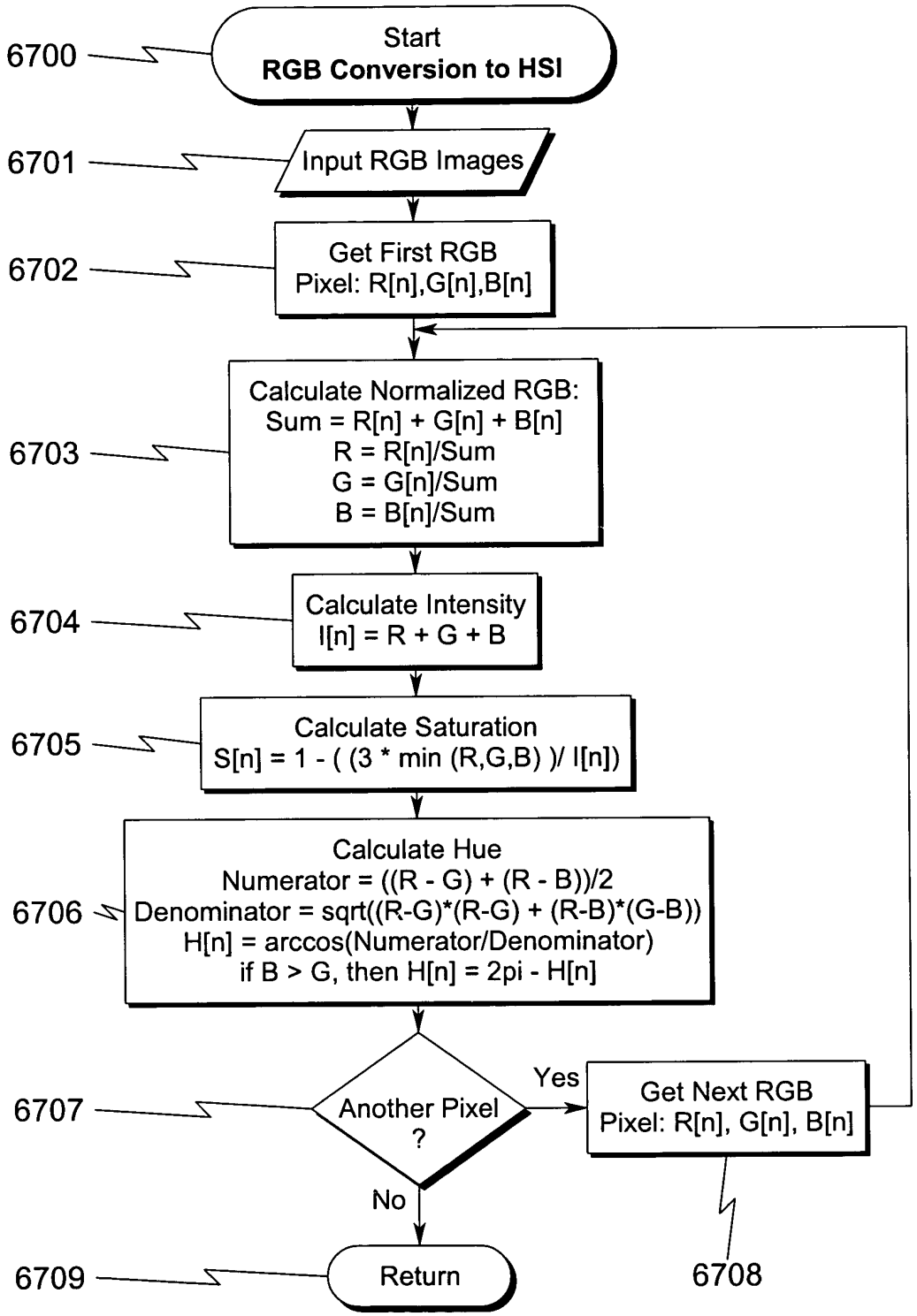

6700
Start
RGB Conversion to HSI
6701
Input RGB Images
6702
Get First RGB
Pixel: R[n],G[n],B[n]
6703
Calculate Normalized RGB:
Sum = R[n] + G[n] + B[n]
R = R[n]/Sum
G = G[n]/Sum
B = B[n]/Sum
6704
Calculate Intensity
I[n] = R + G + B
6705
Calculate Saturation
S[n] = 1 - ((3 * min (R,G,B))/ I[n])
6706
Calculate Hue
Numerator = ((R - G) + (R - B))/2
Denominator = sqrt((R-G)*(R-G) + (R-B)*(G-B))
H[n] = arccos(Numerator/Denominator)
if B > G, then H[n] = 2pi - H[n]
6707
Another Pixel
?
Yes
Get Next RGB
Pixel: R[n], G[n], B[n]
6708
No
6709
Return

FIG. 68

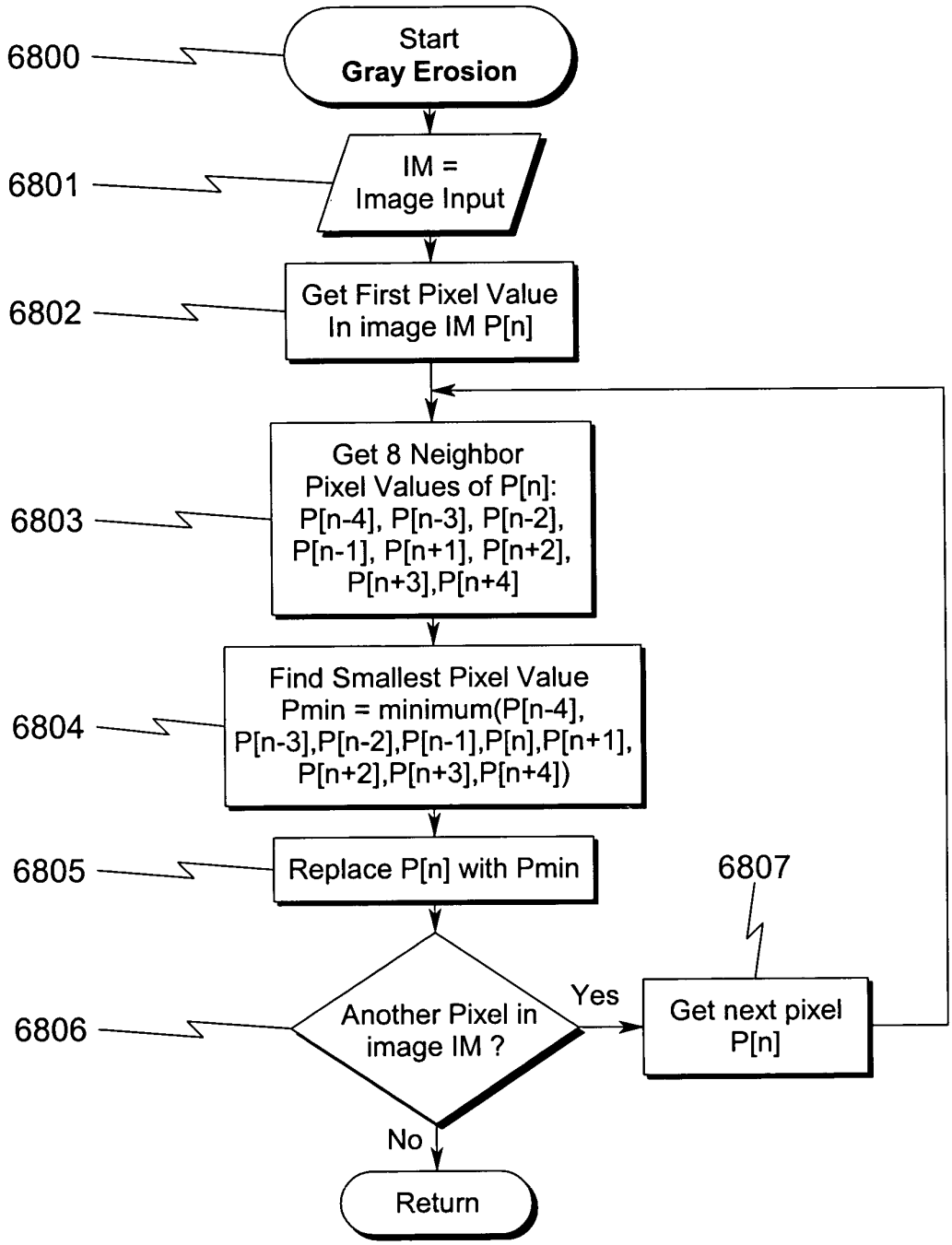

6800
Start
Gray Erosion
6801
IM =
Image Input
6802
Get First Pixel Value
In image IM P[n]
6803
Get 8 Neighbor
Pixel Values of P[n]:
P[n-4], P[n-3], P[n-2],
P[n-1], P[n+1], P[n+2],
P[n+3],P[n+4]
6804
Find Smallest Pixel Value
Pmin = minimum(P[n-4],
P[n-3],P[n-2],P[n-1],P[n],P[n+1],
P[n+2],P[n+3],P[n+4])
6805
Replace P[n] with Pmin
6806
Another Pixel in
image IM ?
Yes
6807
Get next pixel
P[n]
No
Return

FIG. 69

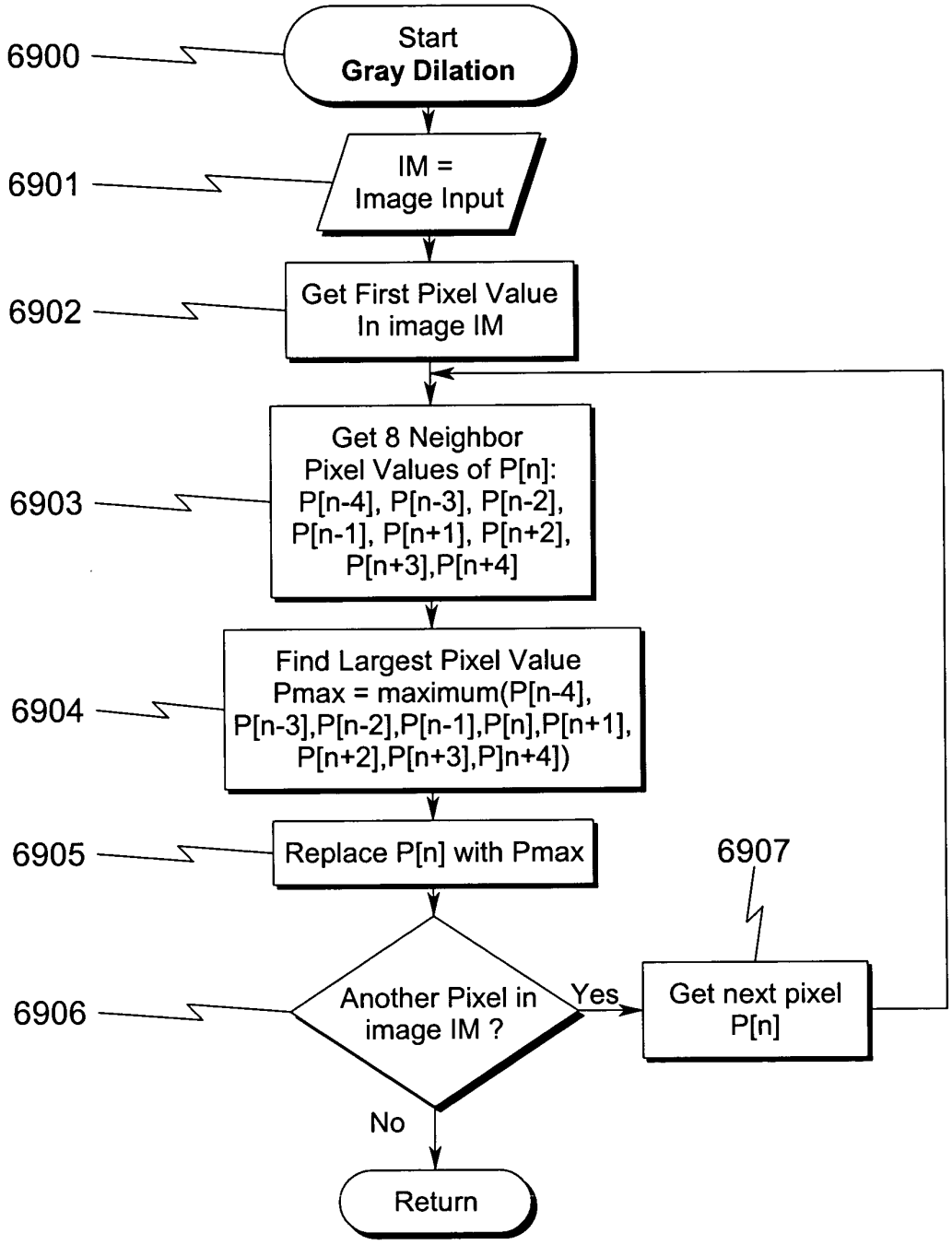

6900
Start
Gray Dilation
6901
IM =
Image Input
6902
Get First Pixel Value
In image IM
6903
Get 8 Neighbor
Pixel Values of P[n]:
P[n-4], P[n-3], P[n-2],
P[n-1], P[n+1], P[n+2],
P[n+3],P[n+4]
6904
Find Largest Pixel Value
Pmax = maximum(P[n-4],
P[n-3],P[n-2],P[n-1],P[n],P[n+1],
P[n+2],P[n+3],P]n+4])
6905
Replace P[n] with Pmax
6907
6906
Another Pixel in
image IM ?
Yes
Get next pixel
P[n]
No
Return

FIG. 70

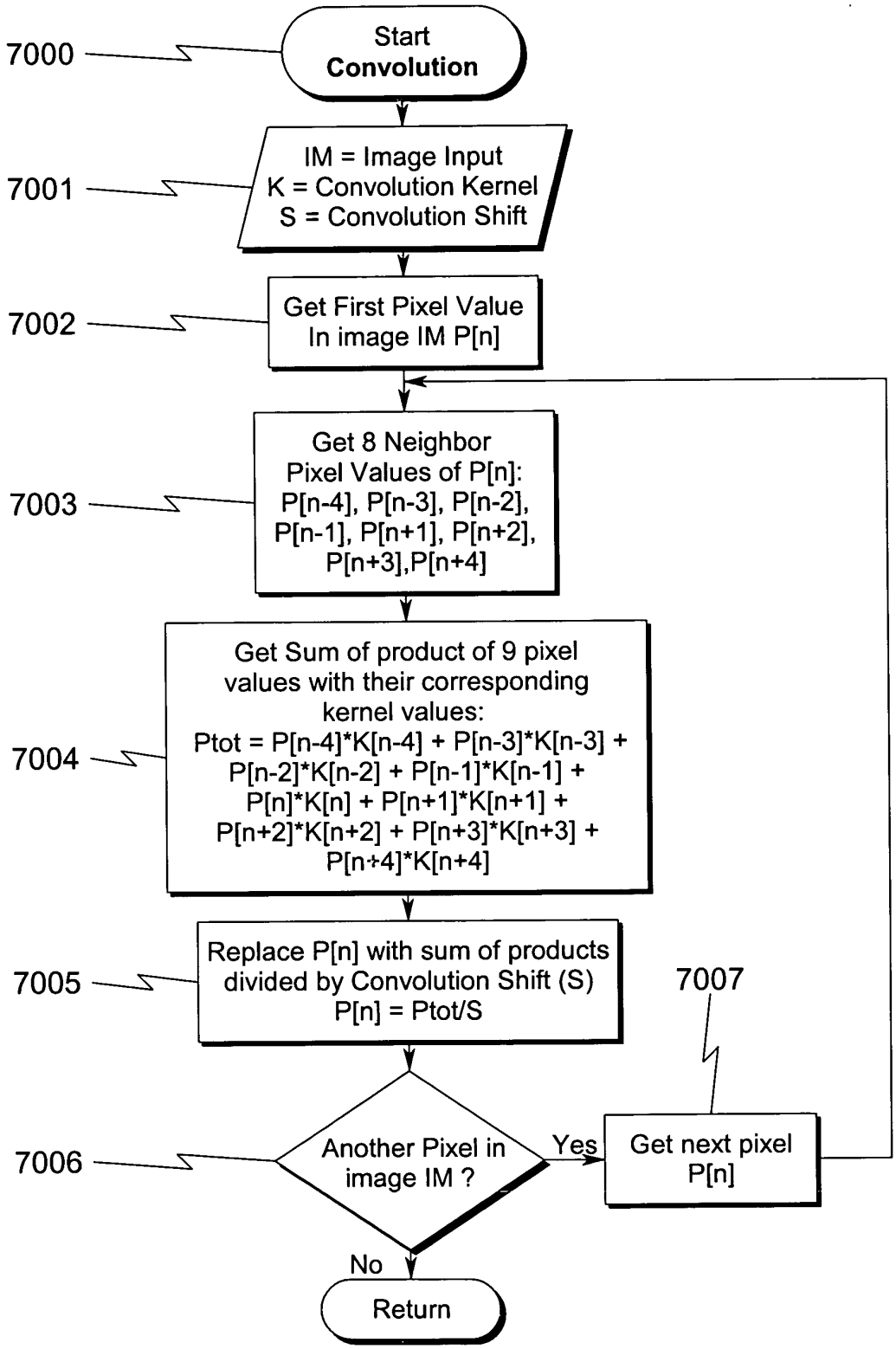

7000
Start
Convolution
7001
IM = Image Input
K = Convolution Kernel
S = Convolution Shift
7002
Get First Pixel Value
In image IM P[n]
7003
Get 8 Neighbor
Pixel Values of P[n]:
P[n-4], P[n-3], P[n-2],
P[n-1], P[n+1], P[n+2],
P[n+3],P[n+4]
7004
Get Sum of product of 9 pixel
values with their corresponding
kernel values:
Ptot = P[n-4]*K[n-4] + P[n-3]*K[n-3] +
P[n-2]*K[n-2] + P[n-1]*K[n-1] +
P[n]*K[n] + P[n+1]*K[n+1] +
P[n+2]*K[n+2] + P[n+3]*K[n+3] +
P[n+4]*K[n+4]
7005
Replace P[n] with sum of products
divided by Convolution Shift (S)
P[n] = Ptot/S
7006
Another Pixel in
image IM ?
Yes
7007
Get next pixel
P[n]
No
Return

FIG. 71

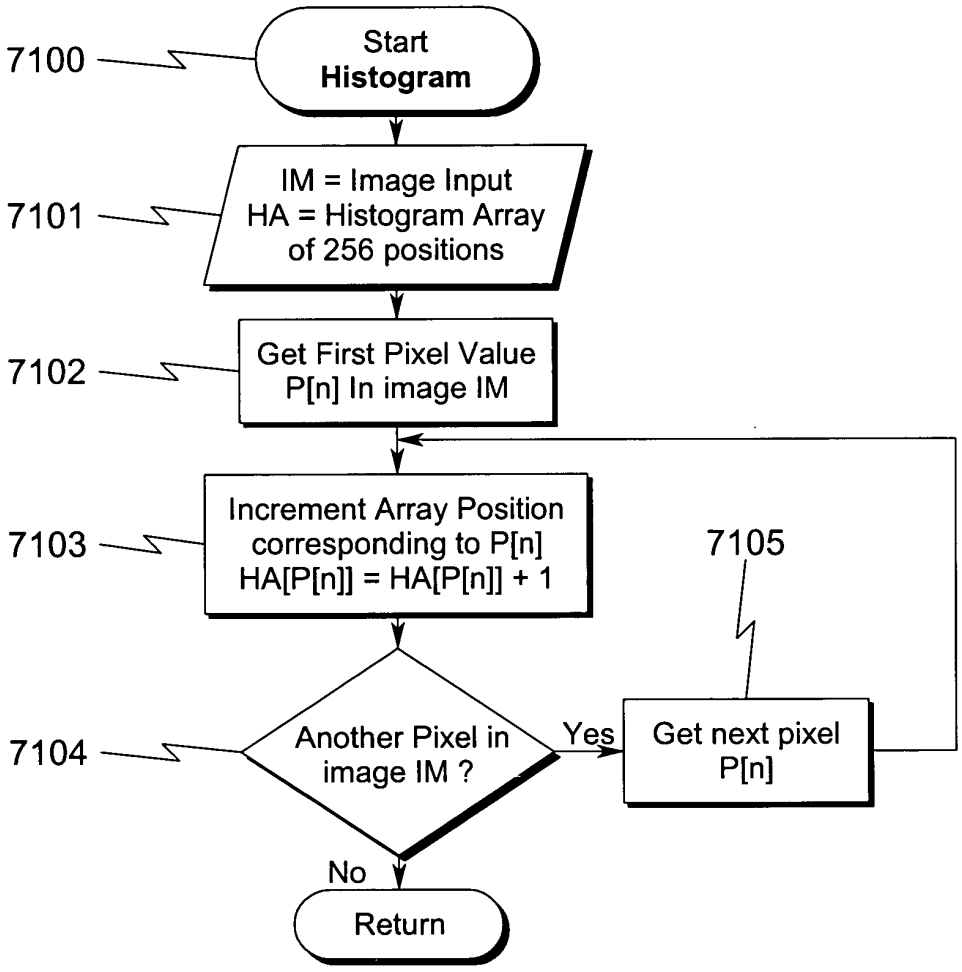

7100
Start
Histogram
7101
IM = Image Input
HA = Histogram Array
of 256 positions
7102
Get First Pixel Value
P[n] In image IM
7103
Increment Array Position
corresponding to P[n]
HA[P[n]] = HA[P[n]] + 1
7104
Another Pixel in
image IM ?
Yes
7105
Get next pixel
P[n]
No
Return

FIG. 72

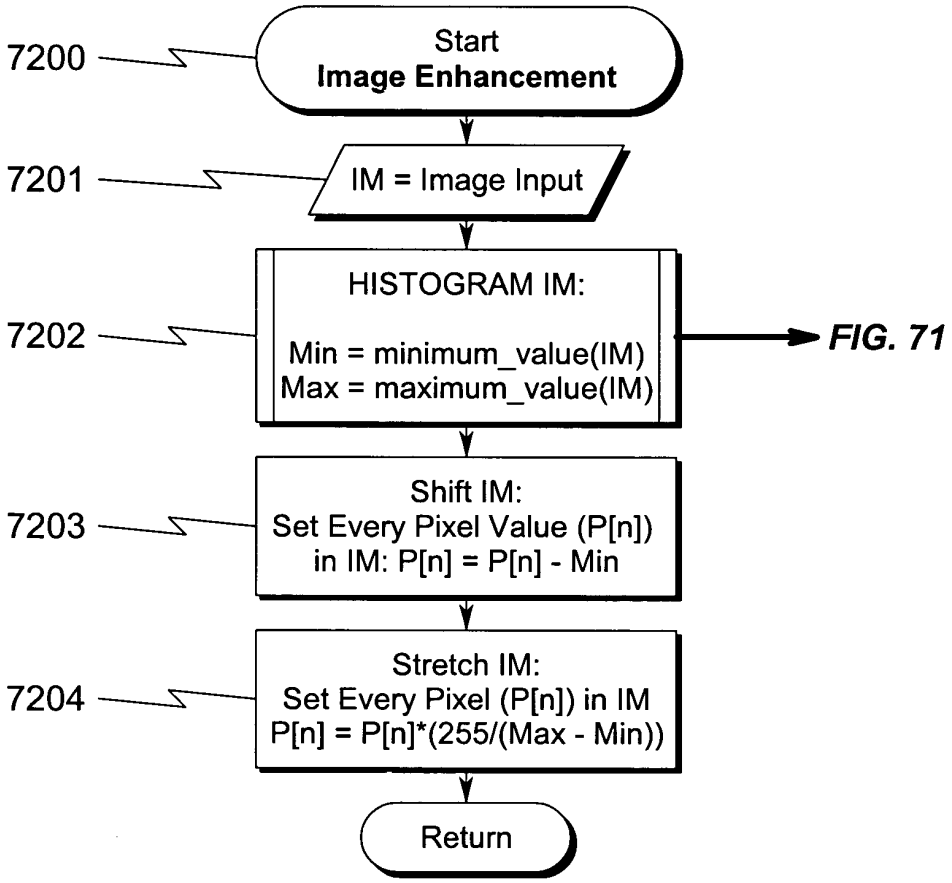

7200
Start
Image Enhancement
7201
IM = Image Input
7202
HISTOGRAM IM:
Min = minimum_value(IM)
Max = maximum_value(IM)
FIG. 71
7203
Shift IM:
Set Every Pixel Value (P[n])
in IM: P[n] = P[n] - Min
7204
Stretch IM:
Set Every Pixel (P[n]) in IM
P[n] = P[n]*(255/(Max - Min))
Return

FIG. 73

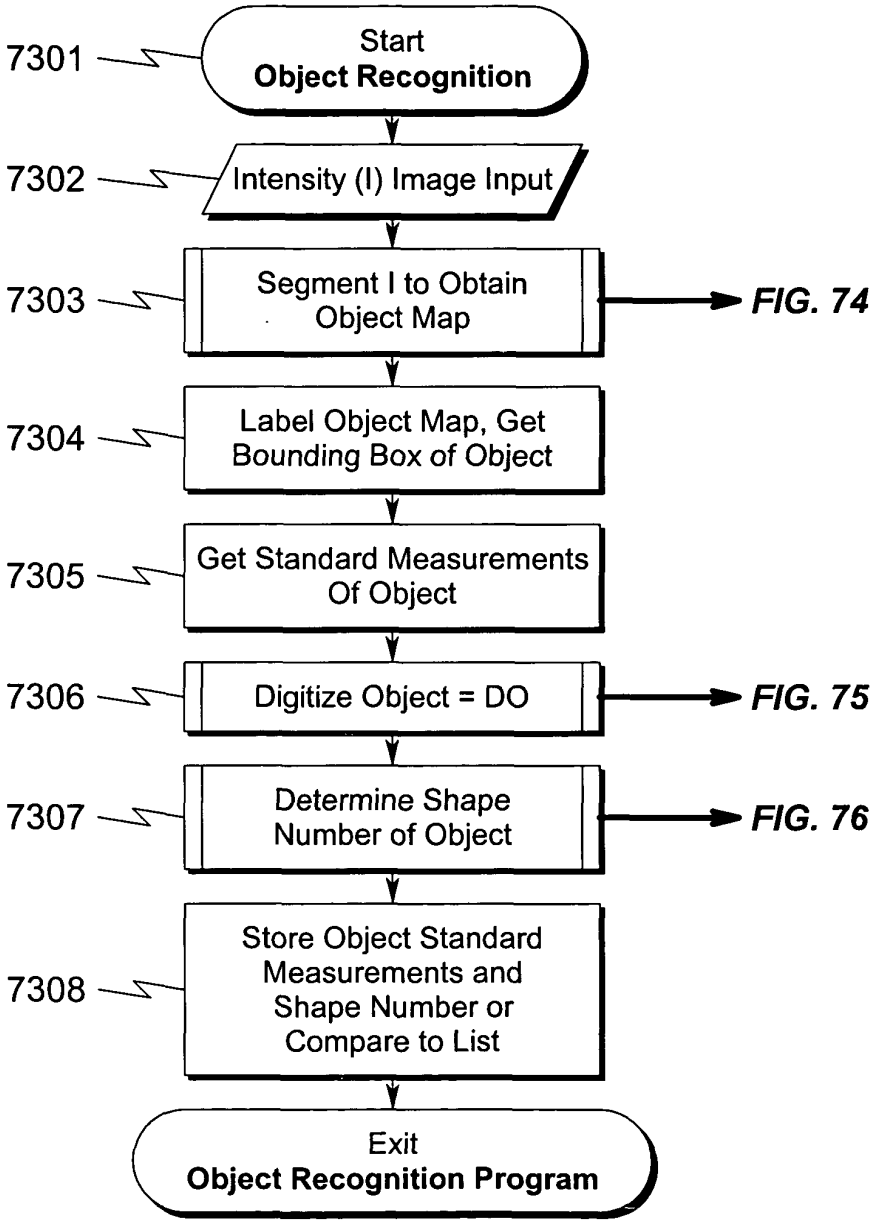

7301
Start
Object Recognition
7302
Intensity (I) Image Input
7303
Segment I to Obtain Object Map
FIG. 74
7304
Label Object Map, Get Bounding Box of Object
7305
Get Standard Measurements Of Object
7306
Digitize Object = DO
FIG. 75
7307
Determine Shape Number of Object
FIG. 76
7308
Store Object Standard Measurements and Shape Number or Compare to List
Exit
Object Recognition Program

FIG. 74

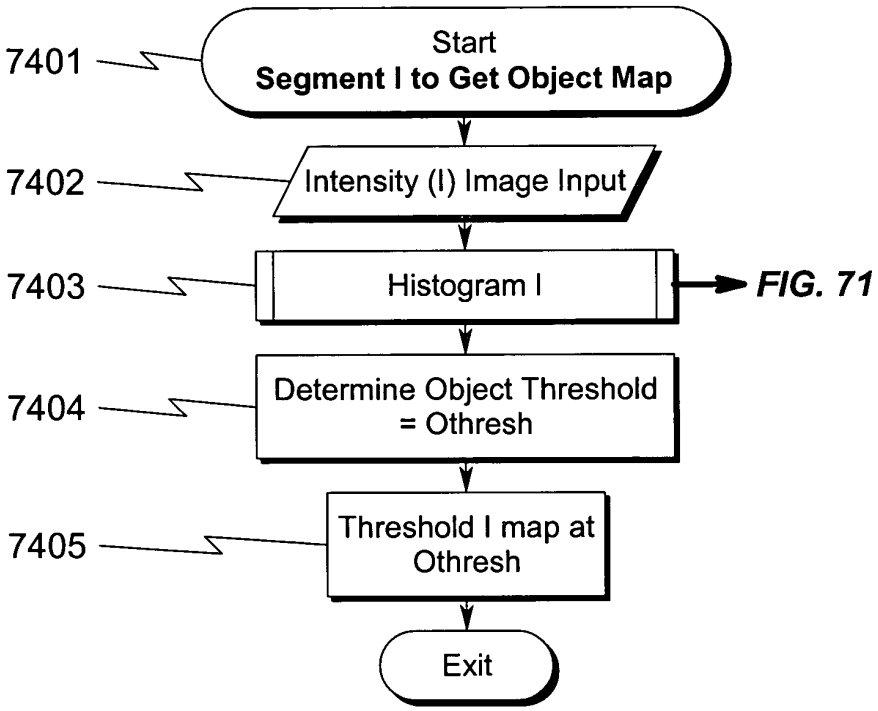

7401
Start
Segment I to Get Object Map
7402
Intensity (I) Image Input
7403
Histogram I
FIG. 71
7404
Determine Object Threshold
= Othresh
7405
Threshold I map at
Othresh
Exit

FIG. 75

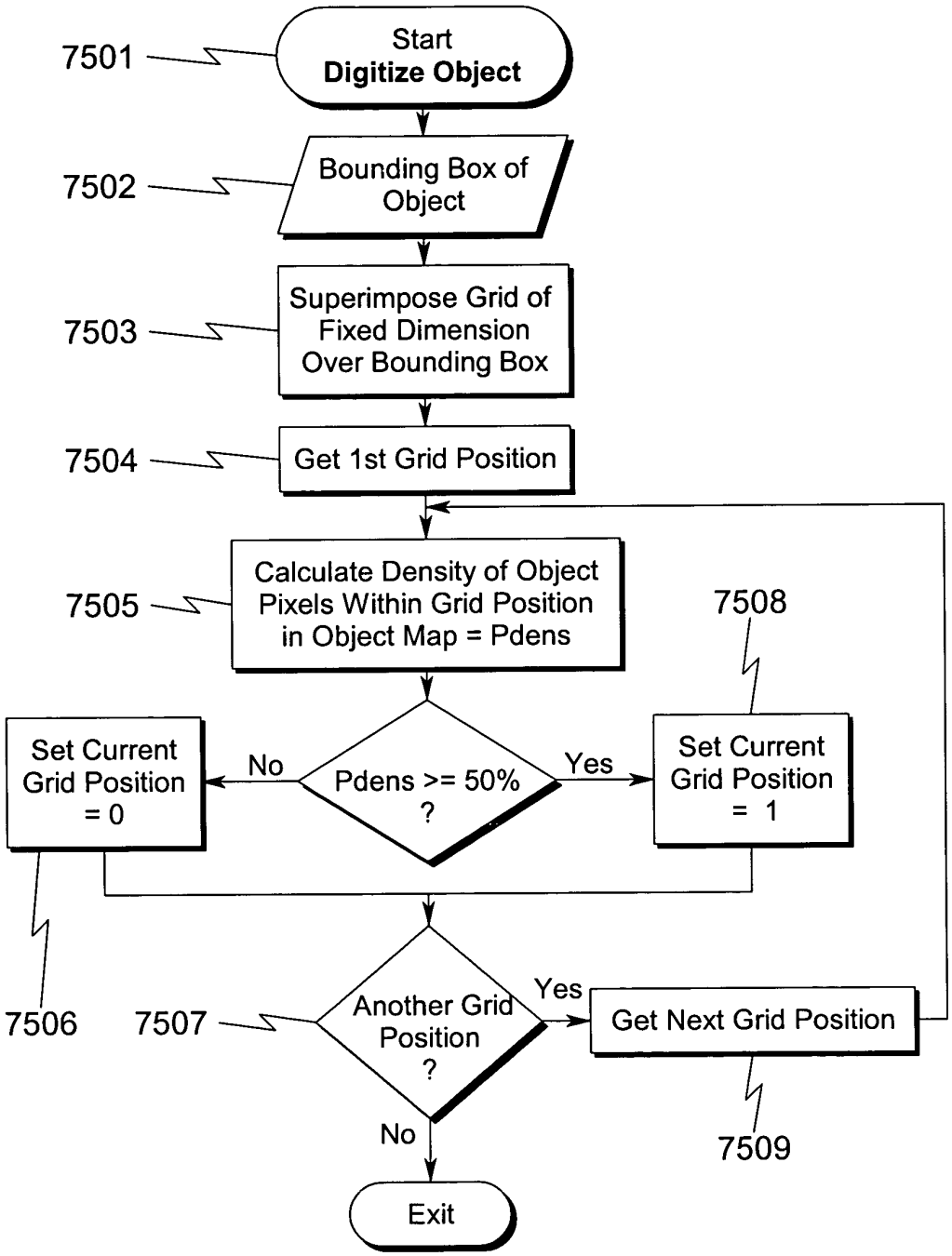

7501
Start
Digitize Object
7502
Bounding Box of Object
7503
Superimpose Grid of Fixed Dimension Over Bounding Box
7504
Get 1st Grid Position
7505
Calculate Density of Object Pixels Within Grid Position in Object Map = Pdens
7508
Pdens >= 50% ?
No
Yes
Set Current Grid Position = 0
Set Current Grid Position = 1
7506
7507
Another Grid Position ?
Yes
Get Next Grid Position
7509
No
Exit

FIG. 76

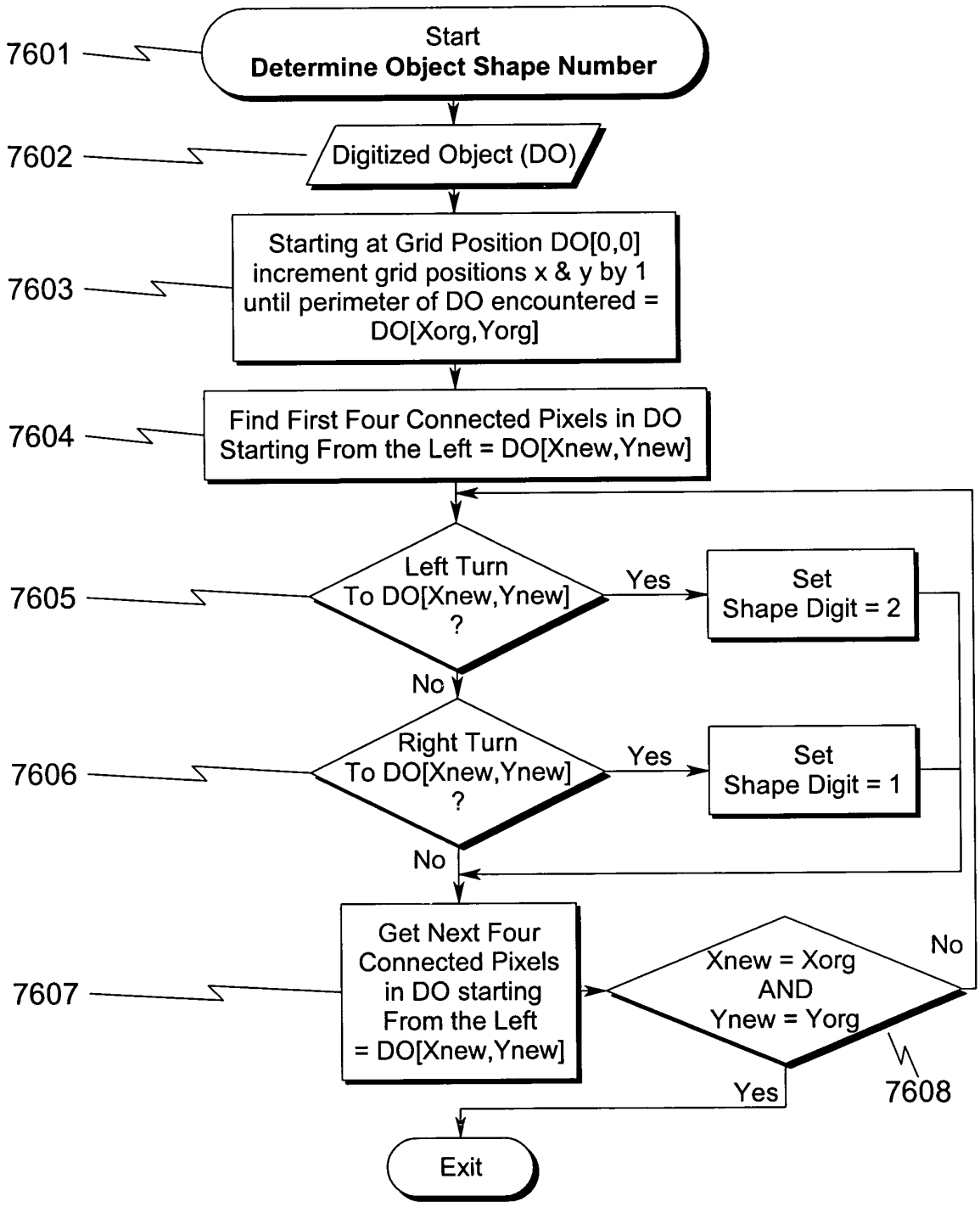

7601
Start
Determine Object Shape Number
7602
Digitized Object (DO)
7603
Starting at Grid Position DO[0,0] increment grid positions x & y by 1 until perimeter of DO encountered = DO[Xorg,Yorg]
7604
Find First Four Connected Pixels in DO Starting From the Left = DO[Xnew,Ynew]
7605
Left Turn To DO[Xnew,Ynew] ?
Yes
Set Shape Digit = 2
No
7606
Right Turn To DO[Xnew,Ynew] ?
Yes
Set Shape Digit = 1
No
7607
Get Next Four Connected Pixels in DO starting From the Left = DO[Xnew,Ynew]
Xnew = Xorg AND Ynew = Yorg
No
Yes
7608
Exit

FIG. 77

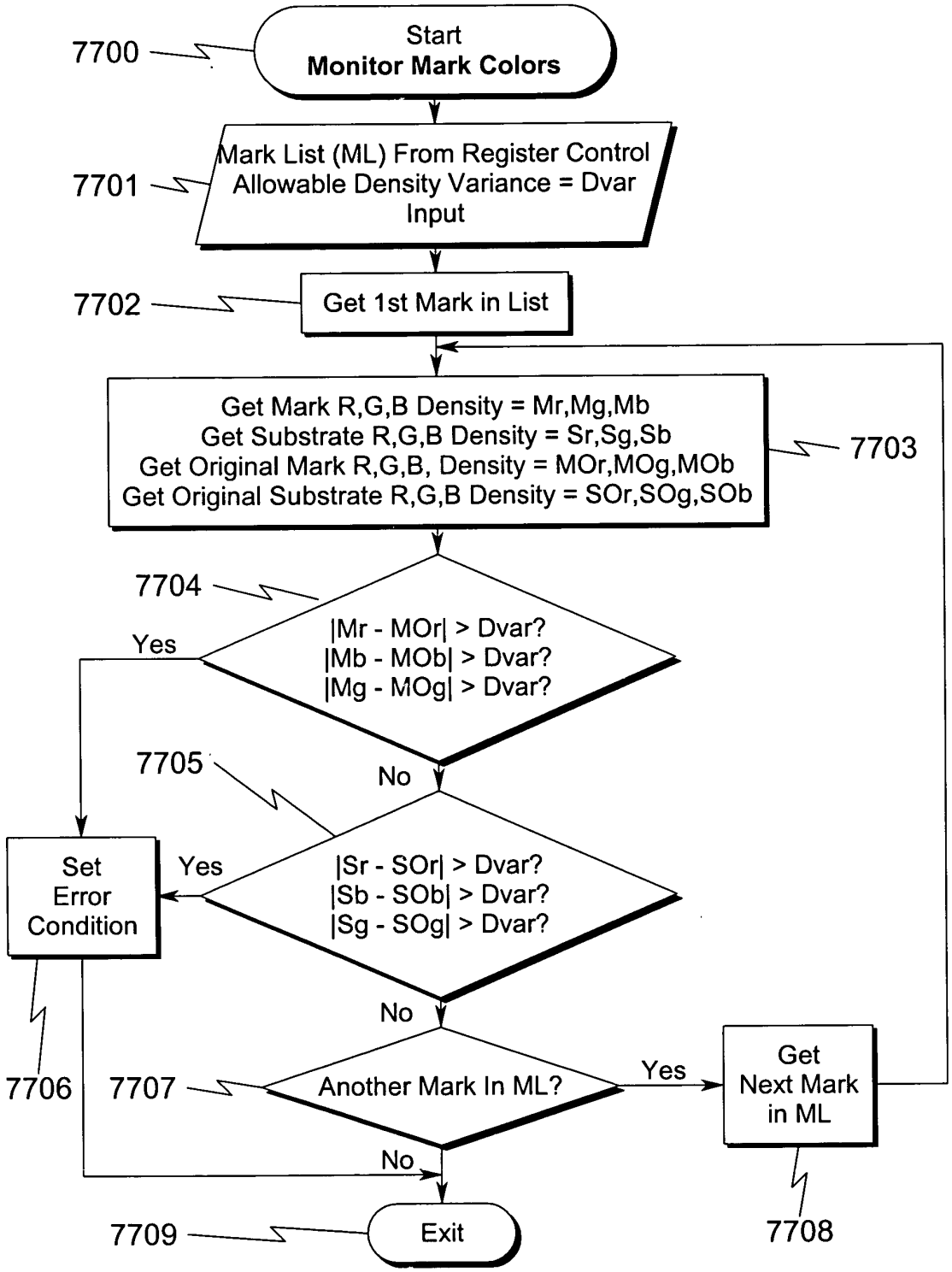

7700
Start
Monitor Mark Colors
7701
Mark List (ML) From Register Control
Allowable Density Variance = Dvar
Input
7702
Get 1st Mark in List
Get Mark R,G,B Density = Mr,Mg,Mb
Get Substrate R,G,B Density = Sr,Sg,Sb
Get Original Mark R,G,B, Density = MOr,MOg,MOb
Get Original Substrate R,G,B Density = SOr,SOg,SOb
7703
7704
|Mr - MOr| > Dvar?
|Mb - MOb| > Dvar?
|Mg - MOg| > Dvar?
Yes
No
7705
|Sr - SOr| > Dvar?
|Sb - SOb| > Dvar?
|Sg - SOg| > Dvar?
Yes
Set
Error
Condition
7706
No
7707
Another Mark In ML?
Yes
Get
Next Mark
in ML
7708
No
7709
Exit

FIG. 78

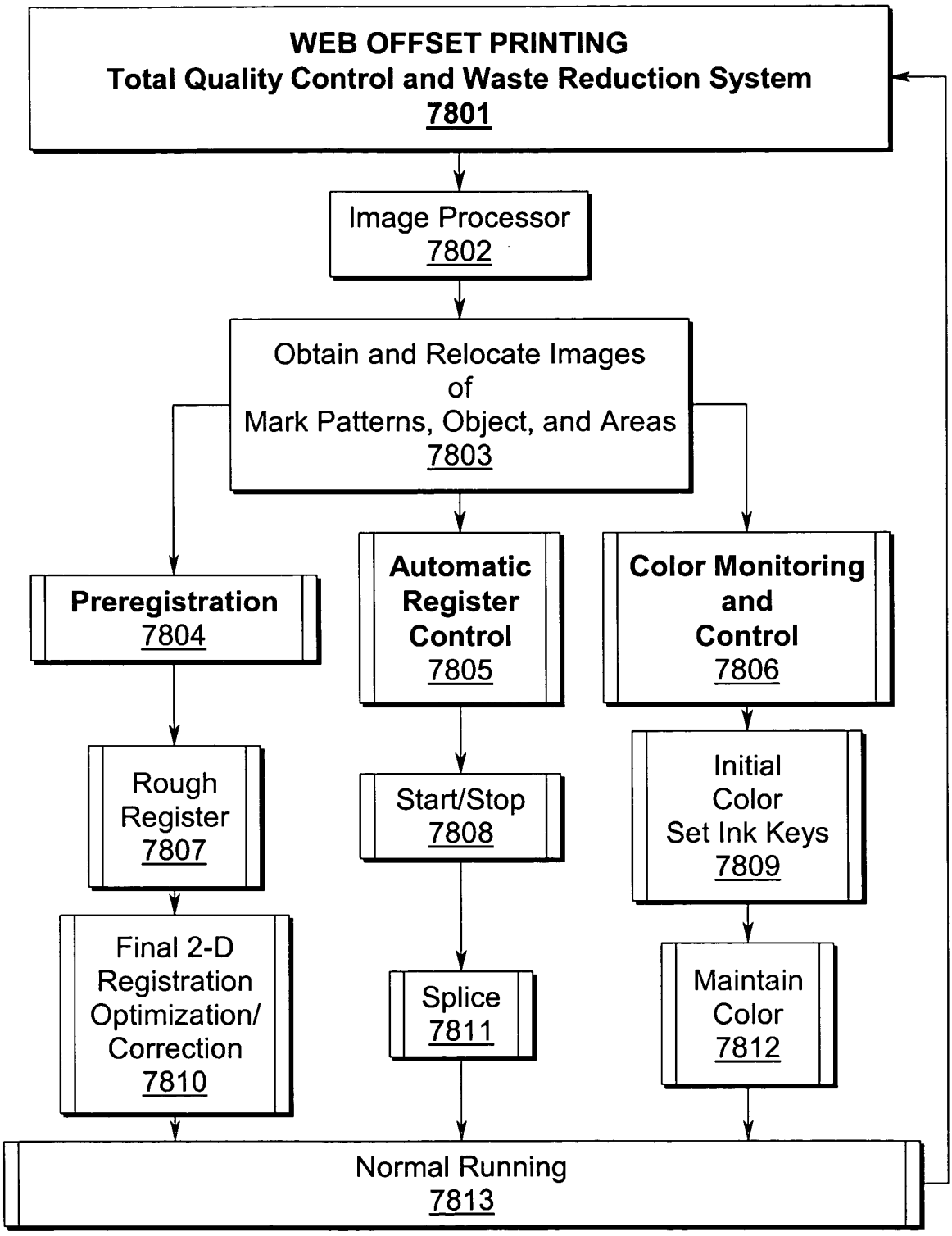

WEB OFFSET PRINTING
Total Quality Control and Waste Reduction System
7801
Image Processor
7802
Obtain and Relocate Images
of
Mark Patterns, Object, and Areas
7803
Preregistration
7804
Automatic
Register
Control
7805
Color Monitoring
and
Control
7806
Rough
Register
7807
Start/Stop
7808
Initial
Color
Set Ink Keys
7809
Final 2-D
Registration
Optimization/
Correction
7810
Splice
7811
Maintain
Color
7812
Normal Running
7813

FIG. 79

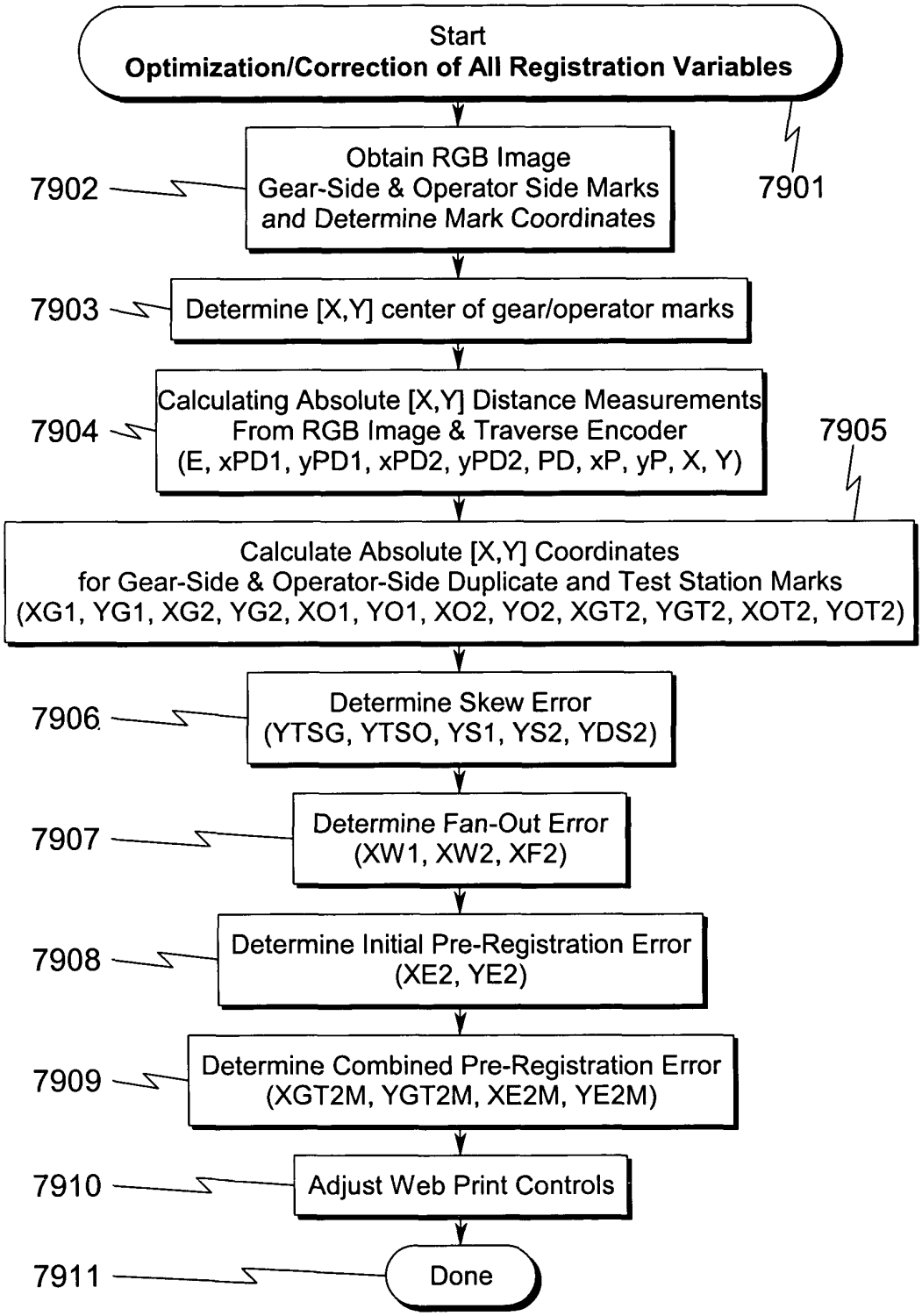
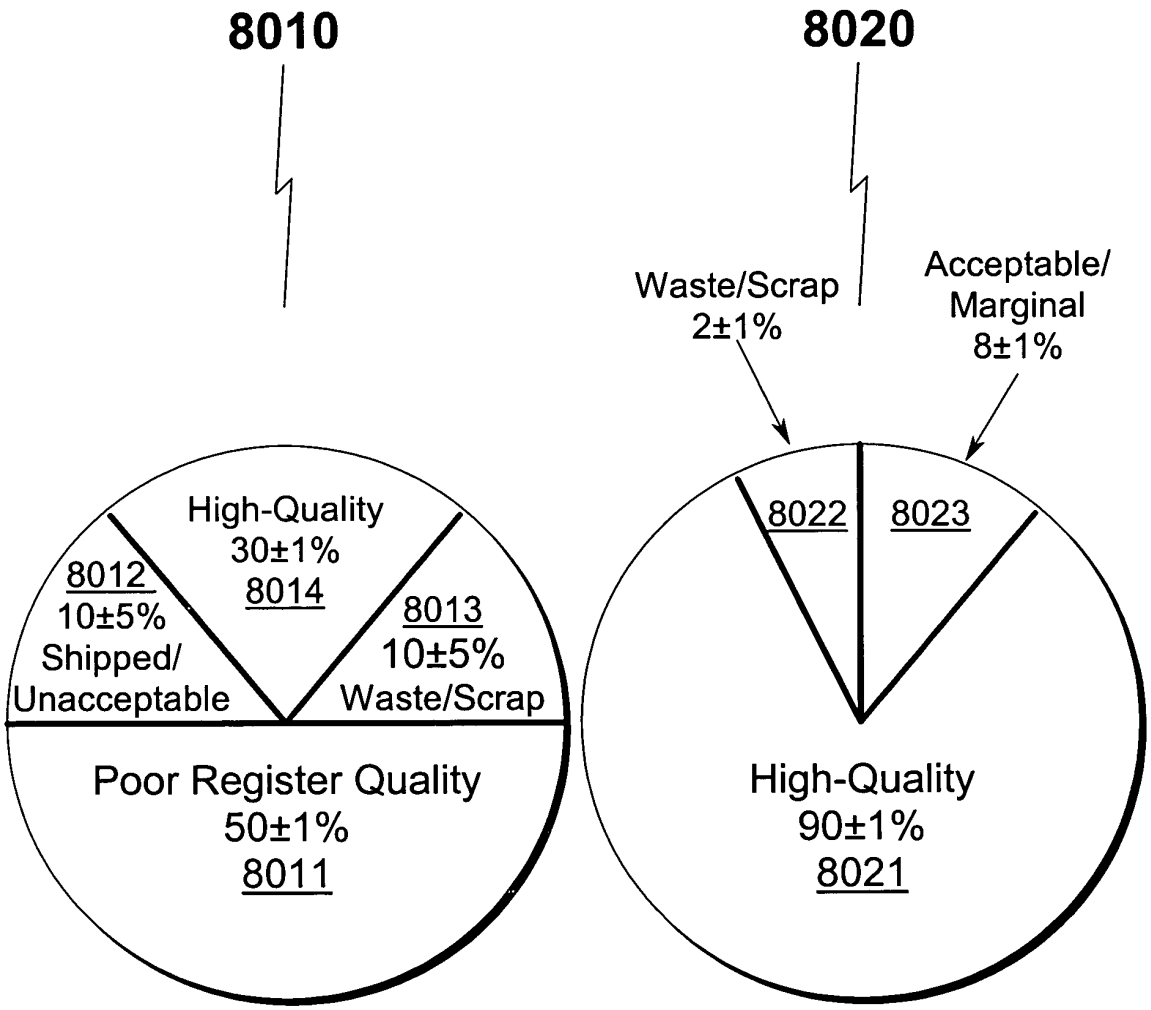

Start
Optimization/Correction of All Registration Variables
7901
7902
Obtain RGB Image
Gear-Side & Operator Side Marks
and Determine Mark Coordinates
7903
Determine [X,Y] center of gear/operator marks
7904
Calculating Absolute [X,Y] Distance Measurements
From RGB Image & Traverse Encoder
(E, xPD1, yPD1, xPD2, yPD2, PD, xP, yP, X, Y)
7905
Calculate Absolute [X,Y] Coordinates
for Gear-Side & Operator-Side Duplicate and Test Station Marks
(XG1, YG1, XG2, YG2, XO1, YO1, XO2, YO2, XGT2, YGT2, XOT2, YOT2)
7906
Determine Skew Error
(YTSG, YTSO, YS1, YS2, YDS2)
7907
Determine Fan-Out Error
(XW1, XW2, XF2)
7908
Determine Initial Pre-Registration Error
(XE2, YE2)
7909
Determine Combined Pre-Registration Error
(XGT2M, YGT2M, XE2M, YE2M)
7910
Adjust Web Print Controls
7911
Done

FIG. 80



Prior Art Product Distribution

Present Invention Product Distribution

Exemplary Newspaper Publication Waste Recovery Profile Distribution

FIG. 81

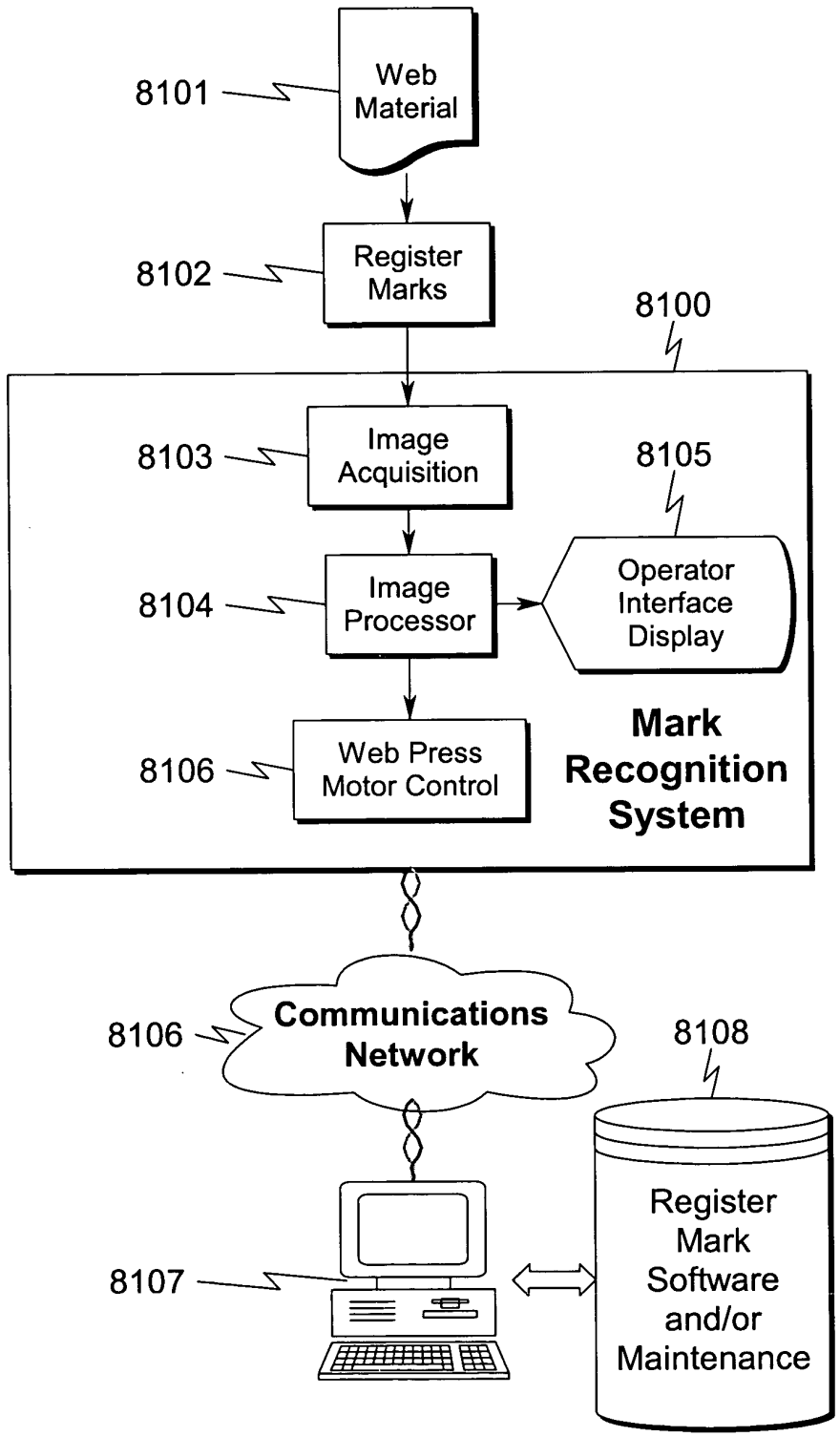

8101
Web Material
8102
Register Marks
8100
8103
Image Acquisition
8105
8104
Image Processor
Operator Interface Display
8106
Web Press Motor Control
Mark Recognition System
8106
Communications Network
8108
8107
Register Mark Software and/or Maintenance

FIG. 82

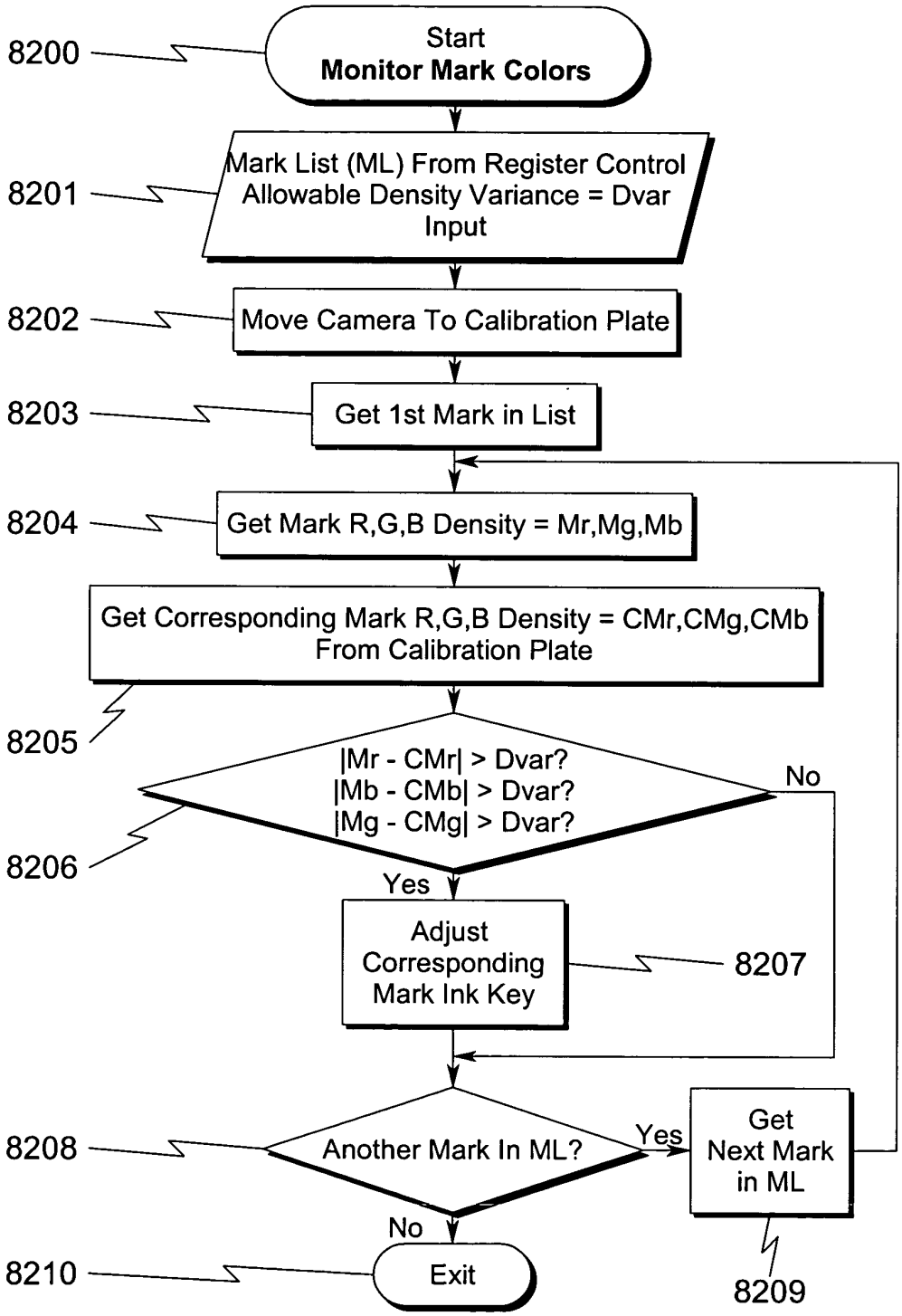
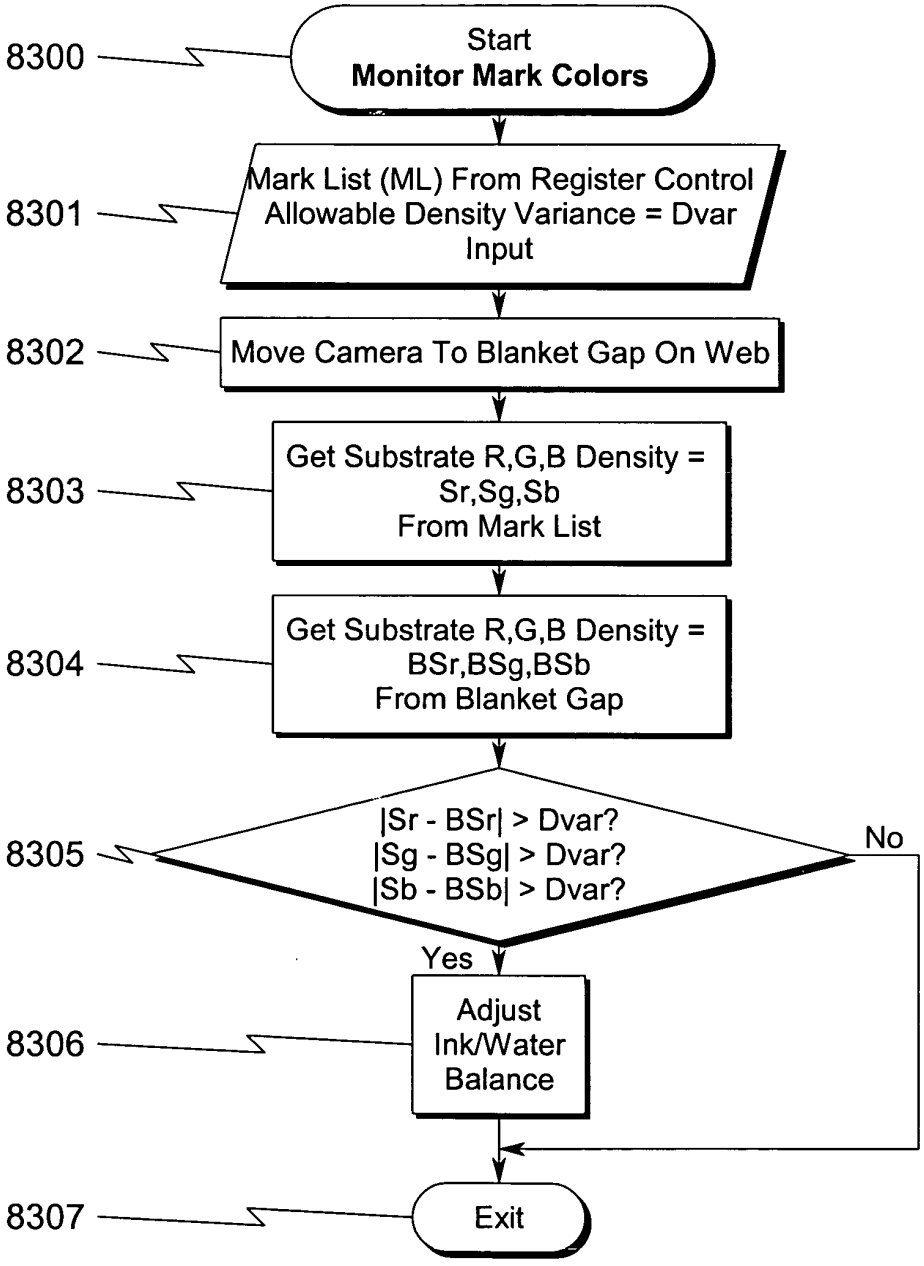

8200
Start
Monitor Mark Colors
8201
Mark List (ML) From Register Control
Allowable Density Variance = Dvar
Input
8202
Move Camera To Calibration Plate
8203
Get 1st Mark in List
8204
Get Mark R,G,B Density = Mr,Mg,Mb
Get Corresponding Mark R,G,B Density = CMr,CMg,CMb
From Calibration Plate
8205
|Mr - CMr| > Dvar?
|Mb - CMb| > Dvar?
|Mg - CMg| > Dvar?
8206
No
Yes
Adjust
Corresponding
Mark Ink Key
8207
8208
Another Mark In ML?
Yes
Get
Next Mark
in ML
8209
No
8210
Exit

FIG. 83


8300
Start
Monitor Mark Colors
8301
Mark List (ML) From Register Control
Allowable Density Variance = Dvar
Input
8302
Move Camera To Blanket Gap On Web
8303
Get Substrate R,G,B Density =
Sr,Sg,Sb
From Mark List
8304
Get Substrate R,G,B Density =
BSr,BSg,BSb
From Blanket Gap
8305
|Sr - BSr| > Dvar?
|Sg - BSg| > Dvar?
|Sb - BSb| > Dvar?
No
Yes
8306
Adjust
Ink/Water
Balance
8307
Exit